SCIENTIFIC AMERICAN SUPPLEMENT. No 1786

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXIX., No. 1786.

NEW YORK. MARCH 26. 1910.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE WOMEN PEARL DIVERS OF JAPAN.—[SEE PAGE 200.]

THE ARTIFICIAL SILK INDUSTRY.—III.*

CONVERTING WOOD INTO SILKEN FABRIC.

BY W. P. DREAPER, F.I.C.

Concluded from Supplement No. 1785, Page 181.

PROPERTIES OF THE FIBERS.

Recognition of artificial silk yarns.—The nearer these yarns approach real silk in their physical properties, the more important will it become to have a satisfactory method for distinguishing between them. The qualitative and quantitative estimation of these different fibers has been studied by Saget and Süvern (Bull. Soc. d'Encouragement, 1906, 540), in comparison with real silk.

The ash in these products is under 2 per cent. Natural silk contains 17 per cent of nitrogen as compared with the following figures for artificial silk:

Nature of Yarn.	Per cent.
Pauly make (Cuprammonium)	.13
Chardonnet (Nitrocellulose) French.....	.15
Chardonnet (Nitrocellulose) German	.16
Lehner (Nitrocellulose)	.07
Nitrocellulose	9.15 to 14.14

It must, therefore, be the different state rather than the amount in which the nitrogen is present in the (reduced) nitrocellulose products which determines its effect in dyeing with basic dyes, if this is the real cause of this phenomenon.

Diphenylamine sulphate is the ready test for artificial silk, and gives the following reactions:

Silk................................	Brown coloration.
Tussah silk.........................	Brown (intense).
Chardonnet & Lehner (Nitrocellulose)	Intense blue.
Pauly, Viscose or Yarmouth silks...	No reaction.

Strength on wetting.—This loss in strength has introduced a serious factor into the manufacture of textiles, but under present conditions this defect is gradually decreasing, and may in time be eliminated. This is seen by comparing figures published in 1900-1901 with more recent figures which are available.

In the year 1900 an isolated test (Bronnert, Bull. Soc. Ind. Mulhouse, 1900) gave a loss of 77 per cent. for Chardonnet silk in strength on wetting.

In the year 1901 Strehlenert gave the following figures:

Yarn.	Dry strength.	Wet strength.	Loss per cent.
China silk........	53.2	46.7	14.1
French (ecrue) ..	50.4	40.9	18.8
Chardonnet silk .	14.7	1.7	89.6
Lehner	17.1	4.3	74.8
Viscose (old)	11.4	3.5	70.0
Viscose (new) ..	21.5	3.5	84.0
Glanzstoff	19.1	3.2	83.0

These figures give an average loss of 82.8 per cent on wetting for the artificial products.

In 1903 Hassack gave the figures, from which the strength per denier has been calculated, as follows:

Quality.	Denier.	Breaking strain in grms.	Do. per denier in grms.	Elasticity per cent.
Genuine silk ..	23	57.5	2.5	21.6
Chardonnet silk*	80	74.2	0.93	8.0
Fismis*	100	71.7	0.71	11.6
Walston*	120	151.4	1.26	7.9
Lehner*	120	171.8	1.43	7.5
Pauly	120	197.6	1.64	12.5
Gelatine	100	63.0	0.63	3.8

* Nitrocellulose products.

Recent figures given by the testing department of the Manchester Chamber of Commerce show the following results:

Yarn.	Dry strength.	Wet strength.	Loss per cent.
Glanzstoff	92.5	31	66
Cellulo silk	75.5	33	56

According to these figures the Glanzstoff product now loses 17 per cent less "on wetting" than in 1901. The cellulo silk product loses still less. The present-day strength (dry) is given by Cross and Bevan at 1.0—1.4 grammes per denier, against 2.0—2.5 grammes for real silk. I think this figure should now be extended to 1.6 grammes for the artificial silk product. The "extensibility under breaking strain" at 13 per cent to 17 per cent for the artificial product against 15—25 per cent for real silk. The average loss in strength on wetting is given at 70 per cent for all varieties (Escalier).

I have recently received a sample of a 25 denier artificial thread containing 66 filaments, which has a breaking strain of 58.5 grammes. This shows a breaking strain of 2.3 grammes per denier. This is quite as strong as some natural silks. A pound of this silk would contain 176,000 yards, which would contain 10,560,000 yards of filaments, or six times the length which a corresponding weight of natural silk of the same size would contain.

Dyeing properties.—No two makes of artificial silk dye in exactly the same way. All the makes on the market dye with the direct, or cotton dyes, as might be expected. The general procedure is to dye at a low temperature, but I have seen artificial silk in mixtures dyed at the ordinary temperature for silk, after a "boiling off" in 1 per cent soap solution for 1½ hours. Ingrain colors do not seem to give fast results on this product; the reason for this is unknown. Difficulties have been experienced in dyeing some dark shades satisfactorily in the past, but these have been overcome.

The cellulose acetate product stands alone in its dyeing properties; it is stated that a dye-bath containing alcohol greatly facilitates this operation.

The nitro-product is not capable of standing the "Lancashire bleach," but samples of cellulo silk have stood it fairly well. Real silk would go into solution under the treatment.

Waterproofing.—The lack of strength in the finished yarn in the wet state has as mentioned been a source of great complaint in the past. Great improvements have taken place in this respect and there are indications that with time this defect may be altogether overcome. Naturally all manufacturers have been engaged in the problem of preventing this degradation of the fiber when wet, due to the hydration of the reprecipitated cellulose. No known process of waterproofing by the application of waterproof materials in a suitable solvent is applicable, or of any real value. An attempt on altogether different lines has been made by Escalier (Monit. Scient., 1908, 13, and patents), who claims that he brings about a condensation of the cellulose molecule by treatment with formaldehyde. The recently published results of the strength of yarn in the dry and wet state certainly indicate a specific action, and that this treatment reduces the tendency for the thread substance to return to the jelly state in the presence of water.

Some years ago the application of formaldehyde for this purpose was patented by Strehlenert (Eng. Pat. 22,540 of 1896), but it was only claimed for nitrocellulose products and was applied to the solution of that substance before squirting.

The only alternative to some such process seems under present conditions to be the use of a raw material which will not hydrate in the presence of water. This material is undoubtedly present in acetylcellulose, and if the working of this material becomes amenable to commercial conditions, any special treatment will be unnecessary. However, cellulose acetate is so waterproof that it will not absorb dyes from aqueous solution. Silk itself has the advantage of not losing its strength in the wet state, yet it is easily dyed.

The loss in strength on wetting is a temporary defect. It is entirely regained on drying. For example, fabrics of artificial silk and silk in mixture were boiled in 1 per cent soap solution for 1½ hours in order to discharge the silk gum from the silk. They have suffered little, if any, deterioration from that process. Care is needed in the handling in the wet state, but it is not beyond the scope of modern dyeing and finishing to meet the necessary conditions, even with very fine counts.

Any further small reductions in the loss on wetting will materially decrease the difference which exists today between the relative strength of these yarns and silk, and bring nearer the time when they may be equal in this and other respects.

Scroop.—The peculiar rustle which silk possesses when dried out of solution of acid is imitated when these artificial fibers are treated in the same manner, so that in this respect the behavior of the two fibers is identical. This fact may, on investigation, give some more definite explanation as to the cause of this phenomenon.

The brilliancy of the fiber in the coarse counts is greater than that of real silk. In the processes dealing with the production of these yarns directly from cellulose, the chief factor in obtaining this is the method of stretching the yarn during drying. The nitrocellulose product, if properly denitrated, is very brilliant, owing to the surface condition of the fibers and as in other makes the continuous nature of the filaments.

Size of Individual Filaments.—The 120-denier thread of to-day varies in the number of the individual filaments, but it may be said not to exceed 25 in number; so that the size of the individual filament may be taken at from 5 to 8 denier. Actual silk averages 2.755 denier per filament. The fine denier cellulo silk (30 to 50 denier) may contain 45 to 60 filaments, so that here the size is about 0.5 to 1.1 denier. The fineness of real silk has been exceeded in this case. In the sample produced of a 15 denier artificial silk thread (Yarmouth make), the individual filaments are 0.33 denier, or roughly ⅛ of the size of those of real silk. This is the first time that such a thread has been exhibited.

WORLD'S OUTPUT OF ARTIFICIAL SILK.

This has been recently given at about 3,000,000 kilos per annum at the present rate of production, against 1,700,000 kilos in 1906 and 600,000 kilos in 1896. These figures indicate an increase of 500 per cent in 13 years.

The nitrocellulose product still heads the list with an output of between 1,300,000 and 1,600,000 kilos. The "copper-ammonia" process accounts for 1,100,000 to 1,300,000 kilos. The production of viscose silk now amounts to 500,000 kilos.

These figures are large, but that will be greatly exceeded in the future. Within three years the viscose production may be doubled, as it is the intention to establish large works in America and elsewhere.

Output of Natural Silk.—The total returns for 1908 of the 24 European conditioning houses amounted to 51,445,000 pounds. These figures show an increase of 30 per cent in a decade (the average for the years 1896-8 being 34,929,400 pounds), to which all the three great producing centers, viz., Europe, the Levant, and the Far East, have contributed. It is, however, significant that the increase in Europe is only 20 per cent, against 50 per cent for the Far East, and 100 per cent for Asia Minor. This last increase is said to be entirely due to the efforts of the Silk Institute at Broussa and the consequent introduction of scientific methods. In France the production of cocoons has not increased during the last years, in spite of large sums paid in State bounties, amounting to over £150,000 a year.

In 1906 227 spinning mills spun 1,732,018 pounds of silk in France. A comparison of these figures with those of the present production of artificial silk which has also been given elsewhere at 5,000 tons per annum, is instructive.

There is no indication that the large production of artificial silk is materially affecting the gradual and increasing production of the real article; especially as the present production is practically confined to high denier sizes (100 and above). These have a use which may be stated generally to be specific to the artificial product. Exactly what influence the finer counts will have on the production of the real product is a matter which must be left to the future.

It is obvious that an enormous industry must spring up before any appreciable result is noticed in the direction of a restricted output of real silk. One can only speculate on the effect of such a revolution, if the finer artificial silk is manufactured down to 15 denier, and ultimately equals in strength the natural product. A rough opinion may be formed as to the future of the industry on the statement made in a report by the United States consul at Lyons that already 30,000 hands are employed in this industry. If this figure is correct—and it may not be very far from the mark—this industry will in the future give employment to a great number of hands, and become an increasingly important branch of the textile industry.

It is interesting in passing to examine the position taken up by some authorities in this country, that there is an advantage in letting other nations work out new processes, and then establishing a position on the market with their early experience and failures before us. The manufacture of this material under the conditions reviewed starts here with a financial handicap, for the leading Continental firms have already written down their works, plant, and rights, to a nominal amount, out of the abnormal profits in the past; they have a trained staff and great experience at their disposal. So that this must be set against any security arising out of such an assured position. On the other hand, it is claimed that in the two processes working to-day in this country, at Coventry and Yarmouth, respectively, the details of manufacture have been more successfully worked out here than on the Continent. The viscose process is working on a large

* Paper read before the Society of Chemical Industry and published in its Journal.

scale at Coventry, and there are indications that the Yarmouth research works may lead to an equally important development in the production and marketing of finer counts. The Flint works is not yet producing yarn.

RELATIVE VALUE OF DIFFERENT MAKES TO ONE ANOTHER AND TO SILK.

However interesting many of the products may be, from the scientific standpoint, after all their commercial value and adaptability are of first importance. It is too early to attempt to define their relative values either from the point of view of cost or their respective physical or chemical properties.

I would suggest, with all reserve, that up to the present time this so-called artificial silk has hardly come into direct competition with the natural product, and that this has been an important factor in favor of its development in the past. It has created and is creating uses for itself. Its selling price bears little relation in its fluctuations to that of real silk; but with the demand in excess of the supply this is not in itself conclusive evidence in this direction, but it tends to confirm other known facts.

With the material now being introduced in finer counts, it may certainly enter into direct competition with silk. The substitute must then chiefly claim advantage on the grounds of price value. With an improvement in strength in both the dry and wet state, competition must increase, as it has done in the past between the natural and artificial indigo, and alizarin products, and be governed by the relative conditions of supply. The last 15 years have seen a marked improvement in strength and so-called elasticity. There is no evidence that the limit has been reached, or even approached.

There is also the question of the relative "covering power" of the yarns when woven. The ordinary makes of artificial silk have only 60 per cent of the covering power of natural silk. With an increase in the number of filaments in each thread a corresponding improvement in this respect naturally follows, as in the cellulo silk product. The limit to-day may be put at 60—75 per cent of that of real silk. So that there is still room for improvement in this direction. The density of the cellulose substance is about 10 per cent in excess of silk, so that a covering power of 90 per cent may be regarded as the maximum under equal conditions.

This is hardly the occasion to do more than point out the financial gain which has ultimately come to those who have carried this industry to its present state on the Continent. Notices which occur in the textile journals from time to time indicate this in detail. The leading companies have paid steady and increasing dividends up to 50 per cent or more (See Dreaper, J. Soc. Dyers and Col., 1907, p. 5, and Dreaper and Davis, *ibid.* 1908, p. 294).

The manufacture of yarns by a process entailing the solution of the raw material as a preliminary step has, therefore, become a reality. It is evident that the future will see an extension of output, due to the growing appreciation of the value of these yarns, and the consequent extension of its uses.

RADIUM IN DISEASE.

AN INFANT BRANCH OF THERAPEUTICS.

ATTENTION has again been directed, says Nature, to the possibilities of radium as a curative agent, by Sir William Ramsay and by Sir Lauder Brunton.

The supply of radium available for the treatment of disease is still so limited that the therapeutic usefulness of this agent has not yet been fully determined. No sooner were indications noted of a prospect of relieving cancer by the use of radium than all the radium obtainable was devoted to this purpose; consequently, its action in less serious ailments is still almost unknown.

In the treatment of cancer, radium has usually been employed in the form of crystals of the bromide. These crystals are contained either in a sealed glass tube or in a button with a covering of thin glass, aluminium or mica. Recently the crystals have been spread in a thin layer upon a flat surface and covered with a layer of varnish. Such buttons and spread preparations are suitable for application to the surface of the body. The glass tubes may be inserted into the interior of tumors, or into orifices of the body; thus, they may be placed in the mouth or nose, in the œsophagus (within a rubber tube), in the rectum, or in the cervix uteri.

Of the three types of radiation given off by radium (the alpha, beta, and gamma radiations), the view commonly accepted is that the gamma rays have a selective action, destroying cancer cells while leaving the normal cells of the part intact, while the alpha and soft beta rays destroy all cells indiscriminately. Means must accordingly be used to prevent the alpha and soft beta rays from reaching the body. A filter consisting of one millimeter (.039 inch) thickness of lead is suitable.

As it is risky to send a patient away with a valuable tube of radium crystals within his body, sealed glass tubes of radium emanation have recently been used (Lancet, December 11th, 1909). They are inclosed in lead tubing one millimeter (.039 inch) in thickness. These tubes of emanation do not differ from the crystals in the rays they emit or in their action; there is, however one important difference; the radioactive strength of the emanation tube decays according to an exponential law in such a way that the strength is reduced to one-half at the end of about four days. Such tubes, of about 10 milligramme (.154 grain) strength, may be placed in contact with a cancerous growth (say in the rectum) and allowed to decay *in situ*. At the end of a fortnight they may be removed, as being then too weak to be of further use.

Other methods have been tried in a few cases; thus, dilute solutions of radium bromide have been given by mouth, and water in which radium emanation has been dissolved has been injected subcutaneously.

Coming now to the results obtained, the accounts are very conflicting. Undoubted relief has been obtained in a considerable proportion of the cases; cancerous tumors have diminished in size, and have disappeared altogether in some cases. But some of the earlier cases reported as cured have since been found to relapse; in some cases the growth has recurred in the original situation, while in others cancerous deposits have formed in internal organs. It seems fairly certain that in some cases cancerous growths may be cured in their early stage by radium, but it is not yet justifiable to attempt to this unless the patient is so feeble (through heart disease or Bright's disease, for instance) that the removal of the growth by operation could not be undertaken.

When the surgeon has declared a case inoperable, radium (or Röntgen ray) treatment is used as a last resource, and the attempt is usually a desperate one. It is something, then, to be able to report the complete disappearance of malignant growths in some of these cases, even though the final result is not a cure. The local treatment of cancerous growths does nothing to prevent dissemination of the disease in the internal organs, and it is with the idea of achieving this result that attempts have been made to cause radium or its emanation to circulate through the body. In doing so it must be remembered that the alpha radiation is giving out its full energy in the body; and since this radiation possesses about a hundred times as much energy as the beta and gamma radiations together, it is clear that for practical purposes we may disregard the effect of the gamma radiation in this connection. Now, we started with the postulate that the alpha rays are indiscriminately destructive, so that if enough is allowed to circulate in the body to destroy cancer cells, the normal cells of the body will also be destroyed. It must be allowed, however, that the observations upon which this postulate are founded are by no means conclusive, and though there is no doubt that the alpha and soft beta rays destroy normal cells far more readily than is the case with the gamma rays, it may still be true that they, too, possess some degree of selective action, if the dosage be regulated with sufficient accuracy.

This branch of therapeutics is still in its infancy, and it would be a mistake either to raise delusive hopes because some cancerous growths have been made to disappear under its use or to declare it useless because disappointments are common. One disease, rodent ulcer, is cured by the use of radium in the great majority of cases, only a few rodent ulcers proving refractory to its use. There are, however, other methods of curing rodent ulcer. The further development of this branch of medical science will be watched with great interest.

THE FRENCH ANTARCTIC EXPEDITION.

THE French expedition under Dr. Jean Charcot, on board the "Pourquoi Pas?" returned to Punta Arenas recently. The early return of the expedition, some weeks before it was expected, is due to a series of misfortunes which limited the range of the expedition's operations.

It will be remembered that this is the second of Dr. Charcot's Antarctic voyages. In 1903-05, on board the "Francais," he carried out an expedition along the west coast of Graham Land, south of Cape Horn, wintering on Wandel Island, in about 65° S. lat., and continuing the voyage to a point off Alexander I. Land in about 68° S. lat. Apart from the additions made to cartographical knowledge of some of the islands off Graham Land, the expedition was notable for the scientific observations and collections secured in the departments of hydrography, terrestrial magnetism, biology, botany, and geology.

Dr. Charcot's latest expedition was designed to extend the work done in 1903-05. The programme contemplated another cruise among the islands off the west coast of Graham Land, whence it was hoped to continue the voyage westward in the direction of King Edward VII. Land; it was also proposed to make excursions southward to investigate the character of the supposed Antarctic continent, and for this purpose the "Pourquoi Pas?" carried a number of specially designed motor sledges. The expedition was liberally subsidized (£24,000) by the French government, and the ship, a barquentine with an auxiliary engine of 550 h.-p., was specially built for the voyage. The French Naval Department, the Paris Museum, and the Prince of Monaco contributed to the scientific equipment, and the scientific staff included, besides Dr. Charcot, who belongs to the medical profession and is an experienced bacteriologist, specialists in hydrography, oceanography and meteorology, tidal and chemical observations, geology and glaciology, natural history, and terrestrial magnetism.

The expedition sailed from Havre in August, 1908, and from Punta Arenas in the following December. Supplies of coal were taken on board at Deception Island (lat. 63° S.), in the South Shetlands, which has become an important rendezvous for whalers. On resuming the voyage the "Pourquoi Pas?" ran aground, and after being re-floated lost her rudder in collision with icebergs. The voyage, however, was continued to Adelaide Island, south of the 67th parallel, and the adjacent coasts were explored for a distance of 120 miles to Alexander I. Land. Being unable to find a safe anchorage, the expedition then returned north and spent the Antarctic winter of last year off Petermann Island, south of the 65th parallel. Though attacked by scurvy and other diseases, the explorers carried out several excursions, and made a careful study of the glaciology of the region. On the return of summer they continued their explorations among the South Shetlands, again visiting Deception Island, and also Bridgman Island (62° S.). The course of the "Pourquoi Pas?" was then directed south and west, and the expedition succeeded in reaching Peter I. Island (lat. 69° S., long. 90° W.). Ultimately the voyage was extended, between the 69th and 71st parallels, to long. 126° W. King Edward VII. Land extends between the 150th and 160th meridians of west longitude.

Graham Land projects northward from the Antarctic Circle toward Cape Horn as a great tongue of land with numerous adjacent islands. It has been visited by several expeditions, but its connection with the Antarctic continent is still a matter of speculation. Westward, in the region south of the Pacific Ocean, Cook and Bellinghausen sighted stray patches of land or appearances of land, presumably part of the Antarctic continent, but the continuous coast has never been definitely traced. Geographically, the value of Dr. Charcot's expedition consists in the work he has been able to accomplish in linking up and defining more clearly the character of these stray patches of coast. Exactly what have been the results of the expedition in this connection can only be determined when his charts become available. As on the occasion of his former expedition, the most valuable feature of the results will probably be the scientific data collected respecting the magnetic, meteorological, hydrographical, and geological conditions in the regions south of Cape Horn. Dr. Charcot was unable to make use of his motor sledges for penetrating the Antarctic continent.—Nature.

Since the beginning of the year two accidents have occurred to reinforced concrete reservoirs in Oklahoma, which have attracted considerable attention from engineers in that part of the country. These accidents, the Engineering Record states, were at Guthrie and Oklahoma City, the two principal cities of the State. In one case it is admitted that in an attempt to secure maximum economy too light sections were employed.

CONSTRUCTING THE PARIS SUBWAY.

A DESCRIPTION OF THE FREEZING PROCESS EMPLOYED.

BY LUCIEN FOURNIER.

THE line No. 4 of the Metropolitan Railway of Paris, extending from the Porte de Clignancourt to the Porte d'Orléans, which will shortly be opened to traffic, accomplishes the crossing of the Seine by means of very interesting and novel methods of construction. In the section between the Rue des Halles and the Boulevard St. Germain, it was necessary to sink caissons under the Seine, the Place St. Michel, the Place St. André, and the Flower Market, to construct steel tubes between these caissons and, finally, to join all these parts to form a continuous tunnel. Of all this construction the part most difficult of execution was the section between the elliptical caisson of the Place St. Michel and the caisson No. 5 beneath the Seine, passing under the street, the Orléans railway, the quay and part of the river bed. The contractor decided to employ the freezing process, which has proved very successful in sinking mine shafts. Here, however, the conditions were different, for the freezing tubes could not be vertical, but were compelled to follow the axis of the tunnel, which, at this point, has a grade of 4 per cent.

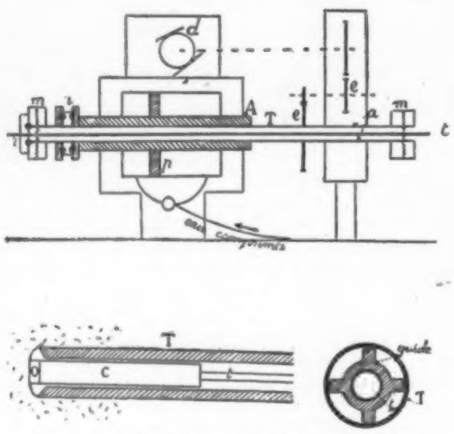


FIG. 1.—DIAGRAM AND DETAILS OF HORIZONTAL BORING MACHINE.

The object of the process was to connect the two caissons by a tube of ice, 213 feet long, and to form, beneath the river, a huge block of ice which would prevent the entrance of water into this tube and the tunnel constructed inside it. In order to make an absolutely watertight barrier it was necessary to place the freezing tubes so near each other that the cylinders of ice formed around them would meet and coalesce. Hence 24 holes were bored parallel to the axis of the tunnel by two boring machines, which were mounted on pylons in the caisson of the Place St. Michel. These pylons supported platforms which could be moved both vertically and horizontally, so that the boring machines could follow the elliptical contour of the tunnel and could be brought to bear on any of the 24 holes.

The boring machines were designed especially for this unusual work. Each machine (Fig. 1) has a hollow shaft *A*, keyed to a hydraulic piston, *p*, by which the shaft can be advanced or retracted. This shaft incloses a second hollow shaft, *T*, which in turn incloses a hollow boring rod, *t*. The inner shaft, *T*, is rotated by an electric motor placed above the apparatus and can be rigidly connected with the outer shaft and the boring rod by means of a sleeve and mandrel. While the boring rod is turned by the electric motor and driven forward by forcing water into the cylinder containing the piston *p*, a stream of water is forced through the boring rod by a small pump, for the purpose of cooling the boring tool and of washing the products of its action back through the space between the boring rod and the tube *T*.

The boring tool *c* (Fig. 1) is a stout iron tube, 10 feet long, terminated by a steel ring set with diamonds or other hard gems, which act like the teeth of a saw as the cutting ring is simultaneously rotated and pressed forward. When the tool has advanced a certain distance, it is retracted into the tube *T*, and the latter, which has a cutting edge in front, is driven forward, without rotating, to the end of the boring. The boring tool is then moved forward and the boring is continued, additional sections of the tube *T*, which constitute the freezing tube, being inserted as the work advances.

From this description it might be imagined that the boring of these holes is an easy matter, but the operation is far less simple in practice, especially when the mass to be traversed is not homogeneous. The lower part of the tunnel, to within a yard of the foot of the arch, passes through a mixture of marl and very hard limestone, containing flints, quartz, etc., while the upper part traverses a stratum of sand, mixed with gravel and flints. This lack of homogeneity made the process very laborious, and the boring of each hole revealed unexpected difficulties which necessitated changes in the method of operation.

In each case the boring was commenced by inserting the end of the tube *T* into one of the 24 holes which had been drilled in the concrete of the elliptical caisson. The velocity of rotation varied from 60 to 500 revolutions per minute, according to the character of the soil. The borer advanced 20 inches in a continuous drive. Six successive drives usually filled it with debris, so that it had to be removed from the hole and cleaned. In some cases the injected water sufficed to keep the boring clear. In working through the upper layer of sand and gravel a new difficulty was produced by pebbles wedging between the tool and the tube *T*. This difficulty was overcome by substituting a boring tool which was so constructed that the debris washed away by the injected water remained inside the tool, but the progress made was so slow (5 or 6 feet per day) that an attempt was made to advance the tunnel at the same time. This produced movements of the soft soil which destroyed the alignment of the borings and broke the tubes and boring rods. In consequence of all these difficulties the tedious process of horizontal boring was abandoned in favor of the usual method, involving the construction of a working tunnel, protected by strong timbers. The total length of the horizontal borings made was less than 300 yards, of which less than 70 yards were in gravel. In short, the contractor's experiment was a failure.

The vertical boring under the Seine was much less difficult, as the conditions were similar to those encountered in sinking mine shafts. The holes were bored to a depth of 59 feet, or to about 3 feet below the bottom of the tunnel, in order to form a block of ice that would assure absolute protection against the infiltration of water from beneath, as well as from the sides. The circulation of the forcing liquid in the tubes sunk in these holes is illustrated in Fig. 2. The tube, closed at both ends, was traversed top to bottom by a smaller tube *Z*, connected with the outlet of the refrigerating apparatus. The freezing liquid flowed down through the inner tube and up through the space between the two tubes, as indicated by the arrows, and returned to the refrigerating apparatus through the tube *X*. The maximum distance between consecutive freezing tubes was equal to the radius of action of a single tube (about 5 feet). Here the cylinders of ice formed around the several tubes were completely united, forming a solid block of ice through which no water could pass.

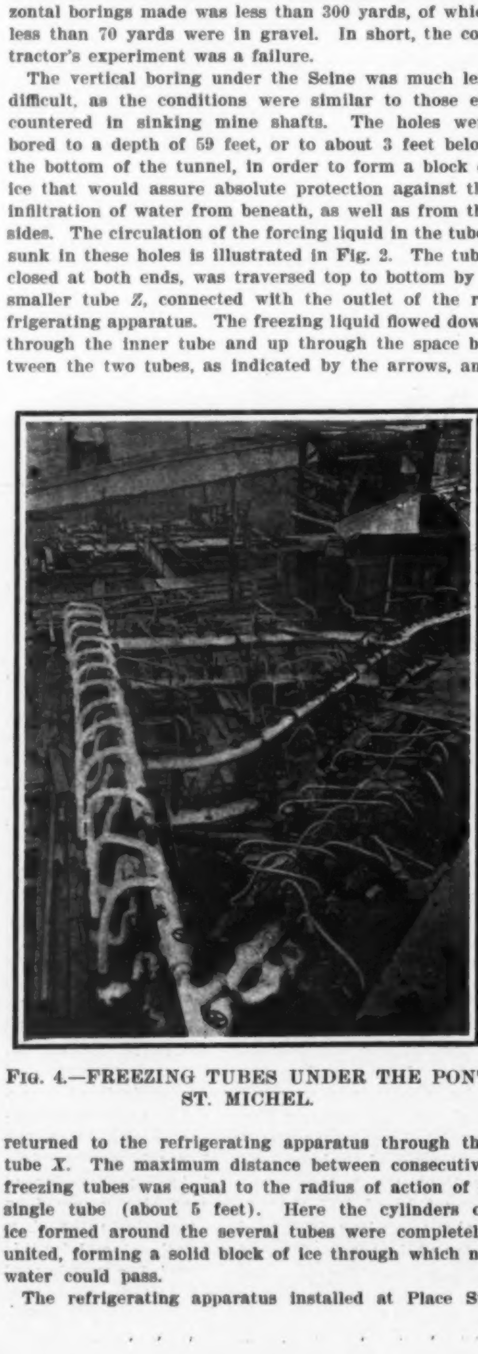


FIG. 4.—FREEZING TUBES UNDER THE PONT ST. MICHEL.

The refrigerating apparatus installed at Place St. Michel, for the supply of the horizontal freezing tubes, was operated by two 100-horse-power gas engines, supplied by two generators of "poor gas." The gas engines operated the ammonia compressor by mechanical transmission, and the electrically driven pumps by means of a dynamo of 220 volts and 350 amperes, which also furnished current for lighting. The refrigerating machine (Fig. 3) contains two cylinders, each of which draws anhydrous ammonia gas from a worm,

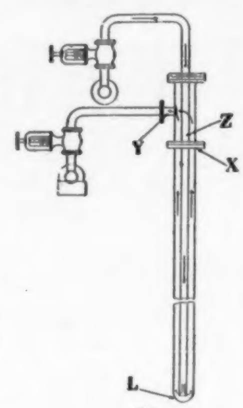


FIG. 2.

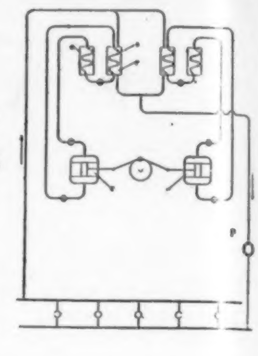


FIG. 3.

FIG. 2.—CIRCULATION IN VERTICAL FREEZING TUBE. FIG. 3.—DIAGRAM OF REFRIGERATING APPARATUS.

immersed in a refrigerating tank, which contains a solution of calcium chloride. The aspired gas is forced into the worm of a condenser, where it is liquefied by a current of cold water. From the condenser the liquid ammonia flows to the worm of the refrigerating tank, where its evaporation, caused by the aspiration of the compressor, still further lowers the temperature of the calcium chloride solution. A rotary pump *P* draws this solution from the refrigerating tanks and forces it, at a pressure of two to three atmospheres, into the distributing mains, whence it flows through the buried freezing tubes and the return mains back to the refrigerating tanks. A second pump, working at a pressure of 15 atmospheres, is employed, in alternation with the low pressure pump, in order to prevent the deposition of solid calcium chloride in the lowest parts of the circuit. The supply of condenser water (176 gallons per minute) was furnished by two rotary pumps installed on the bank of the Seine. This refrigerating plant was capable of producing two tons of ice per hour. The temperature of the calcium chloride solution varied from —4 to —13 deg. F. A smaller refrigerating apparatus, producing one ton of ice per hour and operated by an 80-horse-power electric motor, was installed on the quay for the supply of the vertical freezing tubes. As the larger plant, at Place St. Michel, was devoted to the same purpose, after the abandonment of the horizontal freezing system, it became necessary to establish a connection between it and the river. This connection was made by conduits suspended from the viaduct of the Orleans railway. These conduits were covered with a thick coating of frost.

Unfortunately, it was impossible to sink freezing tubes beneath the Orleans railway or the quay, so that on each side of the tunnel, and especially on the up-stream side, there was a spot where the ice barrier was thinner than elsewhere. Moreover, the walls of the quay rested on quicksand, through which the water forced a passage and, flowing along the nucleus of the ice barrier, prevented its further development. Then the Seine rose, the weak part of the barrier gave away under the pressure and the water invaded the workings. This accident made it necessary to build a coffer dam, 262 feet long, to protect the tunnel during its construction. The refrigerating machines were kept in operation during the entire course of the work, and despite the complete immersion of the freezing tubes and the block of ice in the waters of the Seine, the ice remained perfectly solid until the end.

The application of the freezing process was the last act in the long and difficult work of extending line No. 4 across the two branches of the Seine. The slowness of execution has been criticised, but it should be remembered that the peculiar conditions necessitated the invention of new methods, and their continual modification as new and unexpected difficulties arose. The lessons learned will be valuable in future work. For

example, the method of horizontal boring will be employed in firm, but not in shifting soil. The method of constructing the tunnel almost entirely of caissons, which has since been adopted in other crossings of the Seine, was also first employed in this line.—La Nature.

ELECTRIC DRIVE FOR SHIPS.

AT a recent meeting of the Institution of Civil Engineers of Great Britain, H. A. Mayor, a prominent designer of electrical machinery, read a paper on the application of electric generators and motors for transmitting power from the engines to the propellers of vessels. The following is an abstract of the paper.

At first sight it would appear that on a ship the direct connection between the power generator and the propeller renders unnecessary the use of any intermediate transmission device, and so long as reciprocating steam engines were the best attainable power generators it was possible to correlate the speeds of generator and propeller so as to gain the best efficiency of each. The steam turbine and the non-reversible internal-combustion engine introduce a new set of conditions. On land the turbine holds the field for the largest powers, and because its speed of revolution is unsuited to any ordinary mechanical direct application of power for industrial purposes, its evolution has been directly associated with electrical transmission. These turbines are many of them of the same order of magnitude as the turbines used on shipboard, and therefore a comparison of economy in the two conditions is inevitable.

Land turbines are more efficient than marine turbines for the reasons that the land engineer is freer than the marine engineer to adopt a suitable speed of revolution; that the land turbine runs at approximately constant speed for all loads, and can, therefore, be run on the governor, rendering easier the application of superheat and augmented vacuum; that on land it is possible to subdivide the power units to meet the conditions of varying load, and thus maintain at the smaller loads an efficiency not materially different from the efficiency at the full load of the system; that at sea change of power is directly associated with change of speed, and the whole of the power units must always be in motion while the ship is in motion. The same engine has to run the ship at 10 knots and at 20 knots, although the power varies very widely between those limits. Also the high economy on land of power production associated with electric transmission is largely due to the possibility of exact measurement of power under all conditions of load, giving a complete knowledge of the effect of all changes in the apparatus or in the methods of working it.

The proposition here made is to provide an electric equipment intermediate between the prime mover and the propeller, extending the limits of practical economy in each by modifying the speed restrictions which the prime mover and propeller impose upon one another, and providing that the prime mover may operate at or near the constant speed required for the attainment of maximum efficiency and full power, and that the power expended in driving machinery not required for work is reduced to a minimum or entirely eliminated. At full power all the elements of the generating plant are in full operation and the whole power resources can be concentrated on driving the ship. When full power is not required the generating plant may be shut down in sections.

To accomplish these results special motors have been designed which give the necessary changes of speed and direction and permit the advantageous combination or elimination of the power generators. These motors involve no new electrical principle, but simply mechanical adaptation of well-known designs. Alternating current alone is available for the purpose in question, and normal motors have, therefore, a fixed speed of rotation which is a simple multiple of the generator speed.

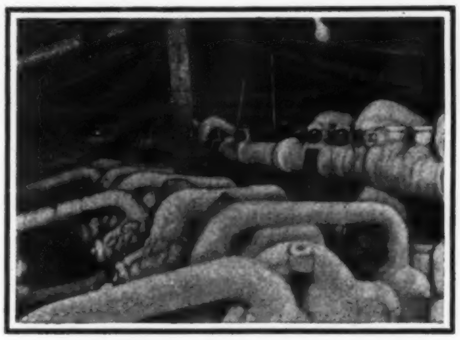


FIG. 7.—FROST-COVERED PIPES.

Two methods of speed change are proposed, each associated with a new form of motor; one of these is designated the "spinner" motor and the other the "multiple" motor. The principle of operation of the "spinner" motor is that an ordinary normal motor driving the propeller at a fixed speed, with the shaft and propeller directly connected, is so arranged as to be rotatable as a whole about the propeller-shaft axis, this rotation being accomplished by a second motor concentrically arranged outside the first, so that the main motor system may be rotated in either direction —again at a fixed speed which is a simple multiple of the generator speed—and the speed of rotation of the propeller shaft and of the propeller in the water is the algebraic sum of the rotation of the main motor and of the rotation imposed upon it by the auxiliary motor.

As both motors are reversible, there are three speeds in each direction: The speed of the main motor system, which is the middle speed; the speed of the main motor system minus the speed of the auxiliary motor system, which is the full speed. The combination may be designed for any three speed ratios, such as 1, 2, 3; 2, 3, 4, etc. Any intermediate speeds required are attainable by adjustment of the turbine or engine governor, which can be operated economically through a range down to about 75 per cent of full speed. The same method is applicable to non-reversible internal-combustion engines.

The "multiple" motor is an ordinary squirrel-cage induction motor in all respects, except that its stator is wound with two or more independent electric circuits each associated with a separate source of supply of energy. For example, the motor may be fed from two sources of supply at 25 and 50 cycles, respectively, the motor windings being for 46 and 92 poles. At full power and speed both windings are in operation under the most advantageous conditions; each of these windings results in a synchronous speed of 66 revolutions per minute. When the 25-cycle current is supplied to the 92-pole winding the speed is 33 revolutions per minute.

Either of these motors permits the use of two or more generators together in a single system without electrical connections or synchronizing devices.

The author then goes on to discuss the application of electric propulsion to certain definite types of ship, and also gives diagrams illustrating the saving in space obtained. The examples worked out are as follows:

1. In a freight vessel of 840 shaft horse-power the normal reciprocating-engine equipment with a single screw would weigh 570 tons for engines, boiler and fuel. The proposed equipment, consisting of three oil engines and generators, three motors and three propellers, would weigh only 270 tons, including fuel. Further, with coal at 20s. per ton and oil at 40s. per ton the saving in fuel cost on a total of £17 would be £5 6s. per day at full power.

2. In a similar freight vessel gas engines might be used. Taking an equipment of 770 shaft horsepower, and using three gas engines and one multiple motor, the respective weights of the normal and proposed equipments would be 446 tons and 229 tons. The consumption of fuel shows an equally favorable comparison.

3. A third freight vessel, but of 1,030 shaft horsepower, is worked out for the purpose of illustrating the application of the multiple motor to steam turbines. One plant drives the ship under normal conditions; extra power is supplied by a small turbo-generator, and is used to keep up the ship's speed in heavy or contrary weather.

4. On a passenger vessel of, say, 16,200 shaft horsepower, the electrical equipment permits of a subdivision of the plant, so that at ship speeds lower than the maximum only part need be run, and that at full power. This advantage is gained without loss in full-power economy, and without additional complication.

Coating for Autographic Drawing Paper.—1. 4 parts starch, 1 part gum tragacanth, 2 parts glue, 1 part powdered Spanish chalk, ¼ part gamboge. 2. 10 parts starch paste, 4 parts gelatine dissolved in 100 parts water, 20 parts Krems white. 3. 30 parts starch, 2 parts alum, ¼ part gamboge. 4. 123 parts starch, boiled to a good paste, 60 parts finest glue, soaked and boiled, 370 parts Krems white in finest powder.

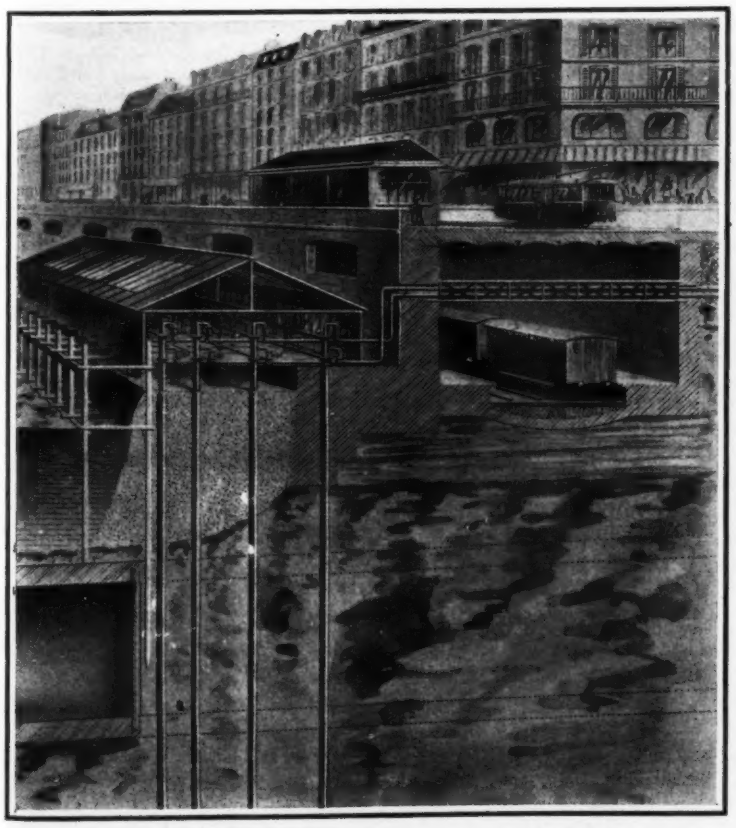


FIG. 5.—VERTICAL FREEZING TUBES AT PLACE ST. MICHEL.

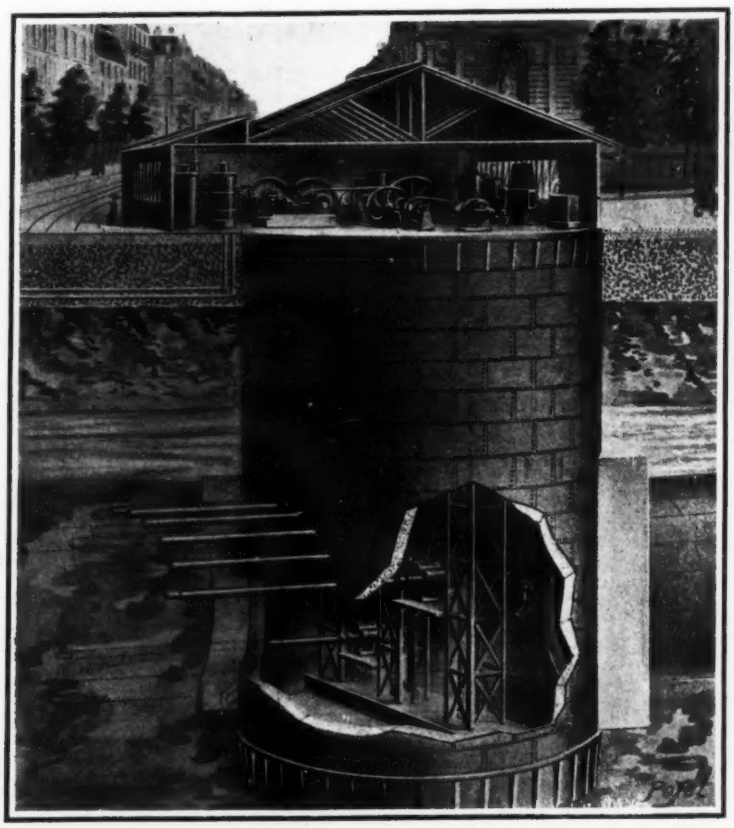


FIG. 6.—HORIZONTAL BORING MACHINES IN THE CAISSON AT PLACE ST. MICHEL.

WRIGHT VS. PAULHAN.

EXTRACTS FROM AFFIDAVITS AND JUDGE HAND'S DECISION IN THE CASE OF THE FARMAN AND BLÉRIOT AEROPLANES.

Concluded from Supplement No. 1785, Page 183.

Finally, therefore, the novelty of the patent arises and this is the special ground of the defendant's attack. I must say that I cannot agree that there has been any acquiescence. The number of persons who can fly at all is so limited that it is not surprising that infringers have not arisen in great numbers; but considering the possibilities it seems to me that the complainants have had an extraordinary number of contests. It is quite apparent that instead of acquiescence, they are to meet and have met with a very determined general opposition.

Hence they must show that the prior art throws no reasonable doubt upon the novelty of their invention. The defendant relies upon a number of patents and prior discoveries which I feel obliged to take up in order.

It must be observed at the outset that several of the citations are from Mr. Chanute's book published in 1894, from which excerpts have been inserted into the moving papers. The descriptions given are, in the cases where it is relied on, too inadequate to constitute valid anticipations under the barbed wire patent, 143 U. S. 276,284. It may be that upon the final hearing the defendant may be able to show these with greater detail, but when he does not show them fully enough to enable me to see that there is some reasonable ground to suppose that they were in fact anticipations, the presumption arising from the patent must prevail. It is not enough that they may have contained some undisclosed elements which might show them to be anticipations. In putting the burden of showing the prior art upon the defendant, even upon preliminary injunction, I am only following the well-settled rule in this circuit.

D'Esterno: The need of caution in regard to evidence of the kind considered in the barbed wire patent, *supra*, is well exemplified in the case of the description of this machine as well as in that of LeBris. It is impossible to say that this had in any sense the combination patented. Apparently the wings were to be fixed at a given dihedral angle and the rear parts were merely flexible. It would be most dangerous, upon the meager and unsatisfactory evidence presented of what the actual machine was, to consider that it raised a reasonable doubt of an anticipation. Moreover, there is no proof that it was ever used or became more than a paper description, in which case, as I shall afterward show, it cannot be regarded as an anticipation.

LeBris: This is a description of the same kind which is too inadequate to understand or to give effect to. So far as one can gather, the wings could be set as a whole at different angles of incidence to the wind. Here too there was apparently a flexible rear portion of the wings.

No one could possibly design either of these machines from the descriptions given, and it would be most extraordinary to suppose that they in any sense contained the combination of elements, worked out after much experiment by the complainants, except by a mere chance that in no sense gave them the necessary vital correlation upon which the patent depends. Moreover, it does not appear that in the case of either of these devices they were known or used in this country except as Chanute described them, and Chanute's description as a printed publication is clearly insufficient to enable anyone to construct them. Thus from no point of view are they good anticipations.

Mouillard: There is a patent in this citation which is a part of the papers and which I have examined. In no one of the nineteen claims is there anything that in any way even foreshadows the patent in suit. Indeed, the machine, which was a glider, had no tail whatever, and to depress the marginal edge of one wing would have only resulted in entirely disturbing the equilibrium which he might have attempted to restore. The depressing of one wing was meant only to turn the aeroplane.

Mattullath: This was an abandoned patent containing full specifications which described six lateral and supplementary planes, three on a side, which were adjustable to different angles and were to be used to promote stability. At the rear was "a rudder secured on a vertical shaft." It does not appear whether this rudder was fixed or not, and the application does not include any use of the rudder to counteract the effect of the differential in the angle of incidence of the supplementary planes. The defendant's brief says that this rudder was to enable the machine "to wheel to right or left." I can find nothing of the sort in the specifications, but for the purpose of the argument I shall assume that the vertical rudder was in fact adjustable.

As an abandoned patent it was clearly not an anticipation. Westinghouse Air-Brake Co. v. Gt. North. Ry., 88 Fed. R. 263. Dr. Zahm swears, however, that Mattullath showed his designs to many persons. It is not enough to show such designs, for until the patent be embodied in some practical form, it is not an anticipation. Ellithorp v. Robertson, 4 Blatch. 307; Det. Lub. Man. Co. v. Renchard, 9 Blatch. 293. At most Mattullath's designs were purely experimental and did not give the public that benefit to which it was entitled, if the patent in suit is to be held to be anticipated and without consideration. Coffin v. Ogden, 18 Wall. 12; Allis v. Buckstaff, 13 Fed. R. 879. In the absence of some showing, which is not suggested, that the complainants borrowed any ideas from Mattullath, his discoveries must be held to be no anticipation.

Zahm: Dr. Zahm in a paper in 1894 suggested the use of slats in the wings so as to create a differential in the angle of incidence, but it was clearly only an ingenious suggestion and did not in the faintest degree show any comprehension of the complicated reactions and necessary correctives which would alone make the suggestion feasible. It was at most only a speculative suggestion never reduced to practical form and fails as an anticipation under the authorities mentioned under Mattullath.

Ader: The most serious attack upon the novelty of the patent in suit is raised over the machine of Charles Ader, a distinguished French engineer, a description of which is contained in Revue de l'Aeronautique for 1893. This being a foreign printed publication, would under the statute be a valid anticipation if it foreshadowed adequately the patented invention.

Whatever may have been the merits of the machine described and actually made by Ader, it is quite clear that the patented combination was not included or understood by him. A reading of his first chapter, pp. 72, 73, is enough to show that he did not regard a rudder as essential. It is not correct to say, as the complainants do, that the vertical rudder was fixed in place. The rear wheel could be moved around a vertical axis and was to be so moved to direct the machine upon the ground. "Une quatrieme a l'arrière pour diriger l'aeroplane sur l'air." "Quand l'aeroplane a un gouvernail vertical celui ci est solidaire de la roue d'arrière et manoeuvre avec elle." The cut shows such a "gouvernail vertical," and we must assume that it was meant to be used and to be turned when the wheel turned.

However, it is also equally clear that the rudder was no part of the machine. M. Ader, with the characteristic clearness of a French mind, enumerates on p. 71 the four necessary primary parts of the machine: "Corps," "ailes," "force motrice," "propulseur," and these he takes up in four separate chapters. The first and shortest chapter concerns the "corps de l'aéroplane," and enumerates seven constituent parts of which the "gouvernail vertical" is not one. The only mention of it is in the sentence I have quoted in full. The whole matter may therefore be disposed of by the single consideration of whether the permissive suggestion of a rudder is to be taken as anticipating the patented combination. In so treating the defendant's contention I shall assume that the machine was not an unsuccessful experiment and that there was an adequate and detailed description of its construction, which showed that the lateral ends of the wings could be warped to different angles of incidence at the will of the operator.

The actual invention of the complainants depends first upon the discovery of the necessary interrelation *per my et per tout*, as Mr. Justice Matthews puts it in the citation quoted above, between the several parts which go to make it up. The mere coincidence of these parts by chance or as a matter of taste was in no sense an anticipation of their functional correlation, in understanding which the complainants' discovery consists and with it their invention. When, appreciating this necessary co-operation of all the elements, they specified their new combination, stating the essential necessity of their union and mutual reactions as the very essence of what they claimed, they invented something new. Ader fortuitously suggested the possibility, as matter of preference, of the third element, the rudder, and so shows conclusively that he did not in the least apprehend the mutually dependent relations between wings and rudder. Thus, the patented combination is not in the least merely a new function of one possible form of Ader's apparatus, which experience might teach an aviator. If the invention be a combination at all, and not an aggregation, it is such solely by virtue of the apprehension of that vital relation of the parts, which Ader conclusively shows he did not have. Nothing but his description could more clearly show that with him the three were in merely nonfunctional aggregation. Nothing can be more clear than that in the patent they are understood as in inevitable combination.

These are the only anticipations cited upon the defendant's brief, so that I may assume that he relies in fact upon only these, and not upon the others cited upon the argument. However, a few words will dismiss all the others in case I misunderstand his position.

Bechtel, Graper, Johnson, Stanley, Marriott: These are all for lateral planes to dirigible balloons. The whole problem is so entirely different when suspension is effected by a reservoir containing a lighter gas than air, that there is not the least resemblance between the patents and the patent in suit. Assume the lateral balance of such a machine to be disturbed by a depression of the left side. It does not appear that an increase in the angle of incidence upon that side would not be adequate to restore it. The resistance so created might have some effect to turn the ship in that direction, but the inertia of the body and the friction would be presumably so great that the equilibrium would be restored without any use of the rudder. Besides, the equilibrium is insured by the fact that in such machines the center of gravity is much below the center of buoyancy, as in the case of a ship in water, and the planes were designed in all cases simply to cause the ship to rise or fall.

Boswell: This is a device to be attached to a dirigible airship, consisting of a plane adjustable in all directions used in connection with a vertical rudder. It is not apparent to me how the tilting of the plane in any of the positions in which it offered no plane of incidence to the drift would cause the ship to turn in one direction or the other, nor how, if it did, it could even then turn it, but, whatever might be its action it was specified simply as a steering device and it is so wholly unlike the patent in suit both in structure and operation that I can see no similarity between them.

Davidson: This is an English patent and is not in the least like the patent in suit.

Lampson: I cannot see any relevancy in this patent.

The importance of the issues involved in this cause must be the execuse for so extended a consideration. It is of course unusual to grant a preliminary injunction before any adjudication and without any acquiescence. However, when the right is not seriously attacked, and when the infringement is clear, the court should not hesitate to interfere. From the showing made I cannot doubt that the complainants first put into any practical form the system of three-rudder control. That there may be other systems is not to the point. Let the defendant use those, if he will. Nor is it necessary to conclude that the complainants were the "first to fly." Upon that I decide nothing whatever, for it is not an issue in the case. All I do say is that I cannot find that anyone prior to their patent had flown with the patented system, and that the changes from the specifications which the defendant had made are no more than equivalents which do not relieve him from infringement.

It is quite clear that for the complainant's protection a writ must go *pendente lite*, because, the defendant being a non-resident, who is here only transiently, there is no way in which they may insure themselves of the monopoly they have acquired except by preventing his use of it at once.

I regret that they have so repeatedly seen fit to accentuate the fact that the defendant is an alien. It cannot be necessary to assert that to the determination of the rights of all persons who come before the court, that fact is totally unimportant; and, indeed, it is by no means calculated to predispose me in his favor that a citizen should believe it a consideration of importance.

The showing before Judge Hazel was substantially the same as that made here, and I should have been disposed to say nothing upon the case except to refer to his opinion, had I not thought it fair to give to the defendant the reasons for reaching an independent conclusion.

AERONAUTICS AND ELECTRICITY.

AIRSHIPS, WIRELESS TELEGRAPHY, AND ATMOSPHERIC ELECTRICITY.

BY H. THURN.

NOT long after the invention of wireless telegraphy it was proved by Prof. Slaby, in conjunction with the Prussian balloon corps, that wireless signals emitted by a land station can be received by a balloon, floating freely in the air. Similar experiments have since been made in various countries. The balloon "Condor," which made an ascension near Brussels, last year, maintained uninterrupted communication with the station on the Brussels Palais de Justice, and also caught signals sent from the Eiffel Tower in Paris.

Prof. Hergesell, the protagonist of practical aeronautics, had already demonstrated the great value of the application of wireless telegraphy to balloons by controlling the valves of unmanned sounding balloons, at heights extending to ten miles, by wireless electric impulses. The receivers of the balloons were tuned to different wave lengths, so that the valve of any one balloon could be opened, and that particular balloon brought down, at will.

The plan of communicating with passing airships by means of optical and acoustic signals has never been carried into effect, because the zone of communication is very limited and the communication would necessarily be restricted to a few scraps of information, as the compilation and the study of a comprehensive code of signals would be very tedious and difficult. The system of signaling by flags, which is used by ocean vessels, would require the maintenance of signal stations at short distances apart, and the rapid passage of the airships would not give time for extended communications. The adoption of wireless telegraphy would obviate all of these difficulties and would do away with the uncertainty which forms so serious an obstacle to the regular employment of aerial vehicles.

A reliable method of uninterrupted communication with the earth is absolutely necessary for the establishment of practical aerial transit. This communication is necessary for the safety of the airship and the development of its highest value as an instrument of sport, traffic or military service; for the reception of information from military scouting balloons, for the direction of the aeronaut at night and in foggy weather, and for giving him warning of approaching storms and weather changes. An airship provided with wireless transmitting apparatus could also call for assistance when in distress, give notification of its probable time of arrival in port, and forward a statement of the men and material needed for repairs.

The radius of action of a military scouting airship would be doubled by the adoption of wireless telegraphy. In a series of experiments made with the German army balloon "Gross II." in the autumn of 1908, messages were successfully sent from, as well as to, the airship. This first of balloon wireless telegraph stations was constructed according to the "Telefunken" system. It was proved, by preliminary experiments in the balloon shed, that the danger of igniting the contents of the gas bag by the sparks emitted by the wireless telegraph apparatus could be averted by taking suitable precautions. This danger is least with airships of the flexible and semi-rigid types, in which the gas bag possesses very few metallic parts which could draw sparks from the highly-charged aerial. The suspension of the car of the "Gross" by hempen ropes insured the complete insulation of the electrical apparatus from the gas bag, and all parts at which sparks were formed were inclosed in gas-tight envelopes. For military reasons, the details of these experiments have not been published, but the results are said to have been very satisfactory.

These experiments have proved that electromagnetic waves are propagated to great heights in the atmosphere and that the part played by the earth in wireless telegraphy is far less important than has been assumed. Thus the principal theoretical objections to the application of wireless telegraphy to airships have been removed.

In the German army maneuvers of last year the "Gross II." demonstrated, for the first time, the practical utility of wireless apparatus on a scouting balloon. The Zeppelin airship which took part in the maneuvers did not possess this advantage. Since that time, however, the "Zeppelin III." has been equipped with wireless apparatus, and it has been proved that, even from a metallic airship of the Zeppelin type, wireless signals can be transmitted with safety to a distance of 300 miles or more. All of the newer Zeppelin airships are provided with wireless apparatus.

Let us now examine the dangers to which a metallic airship is exposed from atmospheric electricity and the employment of wireless telegraphy, and the protective measures which have been proposed. The chief source of danger is the inflammable gas with which the balloon is filled. In a thunder storm a balloon is subject to sudden variations of electric charge which may produce sparks capable of igniting its gaseous contents. Wireless signals are accompanied by equally great and rapid changes of potential, which may produce the same result.

It is probable that the destruction of Zeppelin's airship at Echterdingen was due to atmospheric electric discharges during a thunder storm. The catastrophe which, in September of last year, befell the French dirigible balloon "République," which fell to earth from a height of more than 300 feet, appears to have been caused by the breaking of a propeller blade, which tore a hole in the gas bag, and to the subsequent ignition of the escaping gas by spark discharges between it and the large metal parts of the semi-rigid airship. It is a well-known fact that gas or steam, in escaping rapidly from an orifice, acquires an electric charge which may produce powerful sparks.

As the gas cannot be ignited by discharges from the canvas gas bag, the netting, ropes and similar poor conductors (unless they are converted into good conductors by becoming saturated with water) but can easily be ignited by sparks from the metal parts of the valve and other masses of metal, it is obvious that all metals and other good conductors should be eliminated from the gas bag. There is no objection to carrying metals in the gondola, and a well-conducting drag rope is a safeguard against the danger of explosion in landing. If all good conductors are banished from the immediate vicinity of the gas bag, there would appear to be no danger in the application of wireless telegraphy to airships of the flexible type. If the same precaution is taken, these airships are no more liable than ordinary motorless balloons to ignition by atmospheric electrical discharges.

In rigid airships with metal frames the conditions are altogether different. In an article published in the Electrotechnische Zeitschrift [translated in SCIENTIFIC AMERICAN SUPPLEMENT, No. 1762, October 9th, 1909] Dr. Zehnder has shown that in the Zeppelin airship, with its aluminium frame and its numerous gas bags filled with hydrogen, every condition of easy ignition is satisfied. Between the great cylindrical conducting frame, which is more than 400 feet long and more than 40 feet in diameter, and the surrounding air, may exist a difference of potential of 65,000 volts when the airship is horizontal, and of 500,000 volts when it is steeply inclined. A spark capable of causing ignition can be produced by a potential difference of 3,000 volts. As it does not appear practicable to substitute wood for aluminium in the construction of the frame, Zehnder recommends protection of the airship by lightning rods projecting beyond the reach of escaping gas. He also suggests making the gas container of sheet metal, the stiffness of which might make it possible to employ a lighter skeleton and keep the total weight at its present value. No electrical discharge could take place inside this metal envelope and the induced surface charge would escape harmlessly into the atmosphere from projecting seams and points. As an additional precaution, the aluminium gondolas could be connected with the metal balloon by a number of wires, so that the aeronauts would be inclosed in a sort of Faraday's cage which would protect them from external electrical influences.

In regard to the employment of wireless telegraphy on the Zeppelin airship in its present form, Solff suggests an arrangement of the aerial which would minimize the danger of ignition and would also furnish the best electrical conditions for the transmission of signals. As the hull of the Zeppelin airship is traversed by a vertical shaft or well, it is possible to support the aerial by a simple Eddy kite, which would be kept aloft by the motion of the airship. The wireless apparatus, including the dynamo, would be housed in the middle of the runway which connects the two gondolas. The kite would be connected with the apparatus by a wire from 600 to 1,200 feet in length, i. e., one-fourth or one-fifth the length of the electric waves employed. A second wire, of the same length and weighted at its lower end, would hang downward from the apparatus and would be kept as nearly vertical as possible by insulated stay lines attached to the gondolas. The lower wire might, however, be advantageously replaced by a fan-shaped antenna about 200 feet long, attached to the frame of the airship and projecting about 30 feet below the hull. With this arrangement telegraphic communication would be possible even when the airship was flying very low. Fouling of the propeller by a broken wire could be guarded against by inclosing the propeller in a protecting frame.

The T-shaped antenna which is carried by ships using the Telefunken system could also be applied without difficulty to the Zeppelin airship, as the metal frame is abundantly able to carry a light, hollow mast about 30 feet high, which could be raised and lowered by ropes. The stability of the airship, however, would be affected by this rather complicated apparatus more than by the kite device.

As experiments made with both the military airship and the Zeppelin airship have demonstrated the feasibility of maintaining wireless telegraphic communication between airships and the earth, we may hope that, in the future, wireless telegraphy will play as important a part in aeronautics as it does in navigation. An indispensable prerequisite to its adoption, however, is the electrotechnical development of means of protection from all danger of injury by the working of the apparatus or by atmospheric electricity.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

COLORS OF SEA AND SKY.

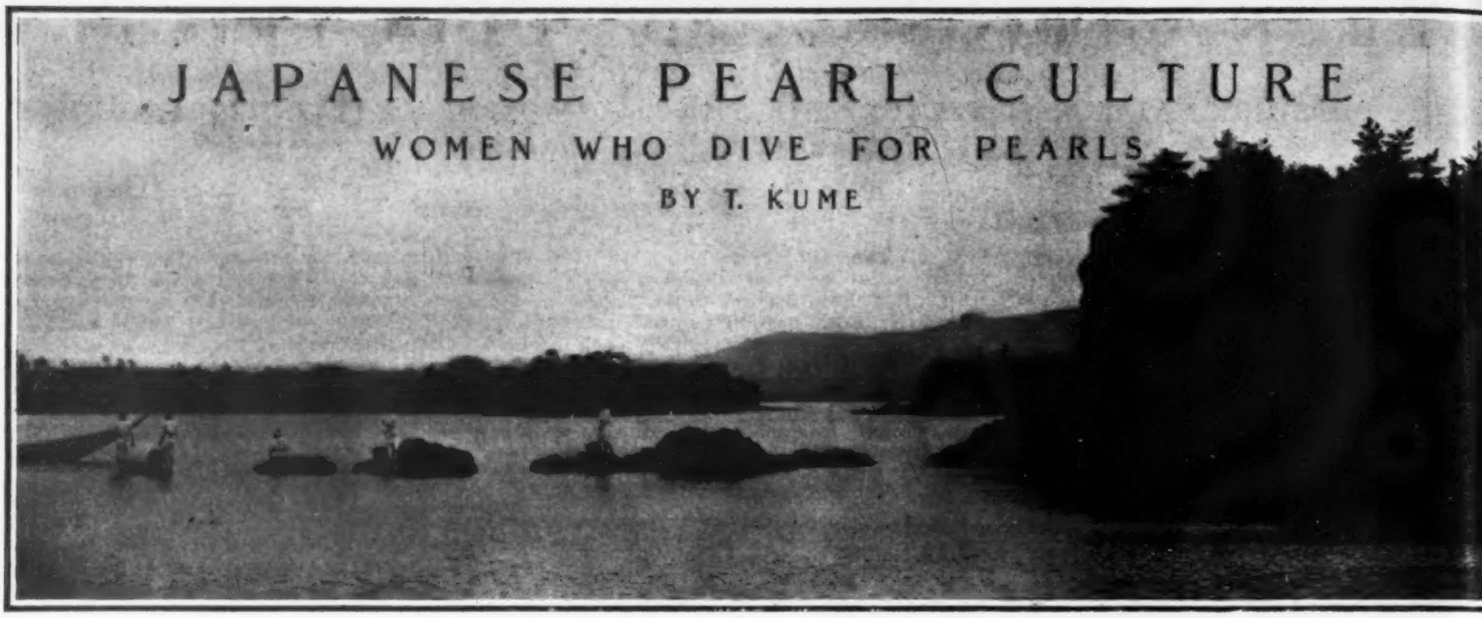
THE Friday evening lecture at the Royal Institution was given by Lord Rayleigh, whose subject was the "Colors of Sea and Sky."

Lord Rayleigh pointed out that for the color of a liquid to be seen properly the light must go through it; hence a deep-colored liquid did not readily show its color. The application of this fact to the color of the sea was direct. The color of the sea was often supposed to be a beautiful blue; that no doubt was what was seen in certain circumstances; but it was due, not to the intrinsic color of water, but to the reflection of the sky. The deep blue color of the sea often came out well when the water was rippled, because then, of the light seen reflected by the observer, more came from the zenith than would be the case if the water was perfectly smooth. With bigger waves, again, it was easy to recognize that the front slope of the wave showed the best blue. The true color of the sea might be seen in rough weather, when looking through a wave with the sun behind it, the observer would perceive no blue, but a fully developed green. In shallow water the reflection of the light from the bottom revealed the true color of the water, except so far as it was affected by the color of the bottom itself. Davy was probably the first to state that the color of water was blue, a conclusion also arrived at by Bunsen. The Belgian physicist Spring made elaborate experiments with water contained in tubes so long as 26 meters, and he described the color as a beautiful blue, comparable only to the purest blue of the sky. But the water must be pure, or it looked green or even yellow. Another inquirer into the question was Aufsess, and one of his observations was that for the blue and violet end of the spectrum, water was almost perfectly transparent, which would sufficiently explain its blue color. Lord Rayleigh himself had carried out some experiments with tubes 12 feet long, and he pointed out the importance of the light used for illuminating them, since a little blue in that light made a great difference to the blueness of the color perceived in them. Experimenting with water from Capri and from Suez he got a color which might complementarily be called blue; but rather was greenish blue, while that from the Seven Stones Lightship, off the Cornish coast, gave a full green. With carefully distilled water he got only the same degree of blueness as with the water from Capri and Suez. Turning to the blueness of the sky, he upheld the view that it was due to the dispersal of light by small particles. Spring's view, that it was due to the effect of chemical matter in the air acting by absorption, he thought was disproved by the fact that the setting sun was red, not blue, though it might be that constituents of the atmosphere, such as oxygen, acted as a secondary cause. The general idea was that the cause was dust, particles of water, etc., but he thought there was no reason to doubt that for the most part the blue of the sky was due to the dispersal of light by the molecules of the air.

JAPANESE PEARL CULTURE

WOMEN WHO DIVE FOR PEARLS

BY T. KUME



THE SHELTERED BAY OF AGO WHERE WOMEN DIVE FOR PEARLS.

WHETHER or not there were any pearls in prehistoric Japan, and, if so, whether these pearls were used for ornament as in our day, is unknown. Even in Japanese tradition and history the ancient references to precious stones, and particularly to pearls, are by no means clear. In the "Kojiki," or the Book of Tradition, the oldest written history of Japan, dating from the seventh century, a word is to be found standing for the present pearl, or "Shinju" in Japanese. In the epic of the goddess "Tamayorihime" a description will be found of a "white jewel," by which a pearl is meant. Still another reference is to be found in the story of the goddess of the sea in her meeting with the god "Hiorino-mikoto," where "giving a pair of jewels from the sea" is mentioned. Indistinct as these mythological references are, there seems to be no doubt that pearls were known even in ancient Japan.

That this should be so would follow from the very nature of the country. Japan is composed of a group of six large and numerous small islands, incessantly washed by the warm waters of the Pacific. In mythological times the people were more or less barbaric. There were no houses, no roads, no commercial or political intercourse. The inhabitants dwelt in caves near the seashore. They settled in one place, and stayed there until their food supply was exhausted. Then they removed to another place, where again they took up a temporary habitation. No doubt sea food was their chief nourishment, and above all shell food. After the flesh had been eaten, the useless shells were thrown aside at the entrance of the caves. Thus the Japanese account for the innumerable mounds of shells which are to be found near the seashore. In these shell mounds no pearls have been found, yet it stands to reason that, if pearls were ever abundant in these prehistoric times, they must have been discovered and prized.

In the reign of the twentieth Emperor Inkyo, which began in the fourth century, the pearl was undoubtedly known. In the "Nippon-Shoki," published 720 A. D., the oldest history after "Kojiki," we read: "In September of the fourteenth year the Emperor Inkyo went to the island of Waji to hunt. Wild animals were abundant at that time, but not one could be killed. All escaped. Then the god of the island said to the Emperor: 'It is I who have hindered the chase. There is a pearl at the bottom of the Sea of Akashi. Obtain that and worship me with it, and I will let you hunt to your fill.'

"And the Emperor gathered about him all the skillful divers that he could find, but not one of them was successful. Finally there came a diver from the Province of Awa, whose name was Osashi. He wound a long rope around him and leaped into the water. After a few minutes he came up and said, 'There is a big "Awabi-shell" twinkling at the bottom of the sea.' Then all exclaimed, 'That is the very thing for which we are seeking. That must be the very pearl prized by the god of the island.'

"Then the diver Osashi plunged in again, and, after a while, he came to the surface with a giant Awabi-shell. At the very moment that he touched the shore he lost breath and died. When they sounded the water by means of a rope, they found it to be sixty fathoms deep. In the giant shell was found a pearl the size of a peach."

Exaggerated as this story is, it contains a suggestion of pearls, and moreover the suggestion that pearls were highly prized. But in the "Nippon-Shoki" there are many references to the existence of pearls and their use as personal ornaments.

Japan has long yielded the most beautiful specimens of Oriental pearls. In Marco Polo's "Island of Chipangue," published in 1298, we read: "They have also pearls in abundance, which are of a rose color, but fine, big and round, and quite as valuable as the white ones. In this island some of the dead are buried and others are burned. When a body is burned, they put one of these pearls in its mouth." Since Marco Polo's time, Kaempfer, Tavernier, Thunberg, and others have written of the beauties of the Japanese pearl.

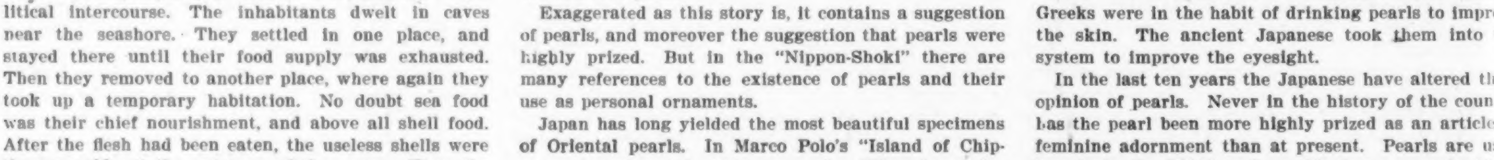
In ancient times Japanese pearls were used more for general decoration than for personal adornment. They were to be found in old lacquer work, desks, furniture or cloisonné work, "inro," "netsuke," tobacco bags, and sometimes in sword handles. One of the oldest pearls used for ornamental purposes is mounted in the statue of the goddess Kannon kept in the Sangetsu-do Temple at Nara. Still another is to be found among the imperial treasures kept in the Shosoin Temple of Nara. These two gems are said to have been deposited in these temples during the "Tempyo" age (A. D. 729-748) and are probably the oldest pearls now in Japan.

The history of Japan contains not many references to the use of pearls in connection with feminine jewelry. Evidently in ancient times there were no brooches, bracelets, rings, or pendants. Only the hair was ornamented. Hence it is that large pearls in old Japan were used only for hairpins and for tobacco bags and for string fasteners, and that many valuable pearls were lapped in cloth. This lapping was attended with not a little superstition. When two pearls were thus lapped together, it was thought that they would multiply in time. Still another superstition was that a pearl wrapped in a cloth was regarded as a family treasure, the possession of which insured prosperity to the family. More curious than these customs is the use of pearls as a medicine. The ancient Greeks were in the habit of drinking pearls to improve the skin. The ancient Japanese took them into the system to improve the eyesight.

In the last ten years the Japanese have altered their opinion of pearls. Never in the history of the country has the pearl been more highly prized as an article of feminine adornment than at present. Pearls are used largely in the "Obidome" or obio fastener, embroidery and the like.

There are many species of pearls in Japan. Among the shells which produce pearls, here given by Dr. T. Nishikawa, are the true pearl oyster (Margaritifera martensi), black-lipped shell (Margaritifera margaritifera), electroma sp., Margaritifera panassæ, Mytilus crassitesta, Pecten yessoensis, Haliotis gigantea, Unionidæ or Naiades, Corbicula, Pinna, Soden, Arca, Tridacna, Ostrea, Tapes, Cytherea, Trigonella, Mactra, Melina, Pecten, Rapana, Turbo, Haliotis, Cassis rufa.

This list comprises some of the best-known species. Among these species, Margaritifera martensi, Margari-



The women along the Bay of Ago and the Bay of Gokasho when they reach the age of thirteen or fourteen years, learn to dive for pearls. Their native towns and villages lie along the seashore. They are in the water almost all the year.

THE WOMEN PEARL DIVERS OF JAPAN.

tifera panassæ, Mytilus crassitesta, and Haliotis gigantea, Unionidæ, yield some of the finest pearls. The best of the so-called oriental pearls are obtained from M. martensi; black, blue, and sometimes greenish pearls from M. margaritifera; yellow pearls chiefly from M. panassæ, and black or dark pearls from Mytilus crassitesta; and beautiful pinkish and greenish pearls from Heliotis gigantea; most of the pink pearls, however, are obtained from Unionidæ.

M. margaritifera and M. panassæ are limited to the region of Byukyu Islands in the southern part of Japan, and Unionidæ to the Lake Biwa and also the Lake Kasumigaura. The others are to be found almost everywhere on the coast. Afo Bay in the province of Shima, Omura Bay in the province of Hizen, Takaoka Bay in the province of Tosa, Nanao Bay in the province of Noto, the islands of Awaji, the island of Tsush Tsushima are most famous for their yields of M. margaritifera and martensi.

JAPANESE ARTIFICIAL CULTURE OF PEARLS.

Recently the Japanese, thanks to the energy of Mr. K. Mikimoto, have inaugurated a new industry which is nothing more nor less than the artificial culture of pearls. Everyone has no doubt often seen shells of mollusks lined with a smooth and iridescent coating which is called *nacre* or mother-of-pearl. This coating, like the rest of the shell, is produced by the animal and is made up mostly of carbonate of lime and an organic matrix which usually presents a laminated texture. The color and brilliancy of this layer differs in various species of shell. For instance, in the ordinary oyster it is of a lusterless white, and in a kind of shell called *abalone* or ear shell (Haliotis), the nacre is of a greenish blue tinge, changing to purple

of all, however, are the products of the true pearl-oysters. These are the pearls which have always been called oriental pearls—"solidified drops of dew," the poets have named them.

Pearls are of many different shapes: some round, some pear-shaped, some egg-shaped, and some of very fantastic shapes indeed. The round, pear-shaped, and egg-shaped ones are known as oriental or virgin pearls, while those of irregular shapes are called baroque pearls. These are sometimes found in the shapes of fish, birds' wings, or creeping worms. The seed pearls, generally used as medicine by the Chinese, are always very small and usually found together in numbers.

Sometimes two pearls will be found joined together by the nacreous substance, thus forming what is known as "twin pearls."

All these are called free pearls because they are found in the tissues of the animal's body and are not joined to the shell.

In the same way that twin pearls are joined it sometimes happens that pearls are found attached to the inner surface of the shell. This position interferes with the symmetry of the pearl so that when it is taken out of the shell it is flat on one side, making what is known as a "perle boutan." The attached pearls are not always of inferior quality, but are often highly valued. The world-renowned "Southern Cross," which was valued at $50,000 by the company to which it belonged, was found off Cossack, western Australia, attached to the central part of the inside of a shell.

CULTURE PEARLS.

When once the nature of pearls was understood, it was but natural that many experiments should be

abalone shell. The public was naturally greatly interested, and the newspapers in Europe and America applauded his success and called it a great discovery.

It may perhaps come as a surprise to many that before Dr. Boutan's attempts, a very extensive and successful system of pearl oyster cultivation had been carried on in Japan by a Mr. Mikimoto, and "culture pearls" had not only been produced but placed regularly on the market. Even at the present day, it may be claimed that this is the only pearl-oyster farm in the world which undertakes the extensive cultivation of the precious mollusk and produces "culture pearls" on a commercial scale. An account of this successful enterprise may therefore be not wholly devoid of interest.

THE HISTORY OF THE JAPANESE CULTURE PEARL.

At the Third National Industrial Exhibition held in Tokyo in 1890, Mr. Mikimoto exhibited in the aquarium of the fisheries section some living specimens of the pearl oyster. This made him acquainted with Dr. Mitsukuri, professor of zoology in the Imperial University, who first suggested to him the possibility of cultivating pearl oysters and of making them produce pearls by the use of proper stimuli. Being deeply interested in the subject, Mikimoto went afterward to the Marine Biological Station of the Imperial University at Misaki, where the professor was staying, and learned from him many facts concerning pearl formation and the natural history of the pearl oyster.

Mikimoto's home was Toba in the province of Shima, one of the localities in Japan famous for large yields of pearls. Directly after his return there he began experimenting on his idea. At first it seemed almost like pursuing a fleeting shadow, and his friends

The women pearl divers of Japan wear a special dress. The hair is twisted into a hard knot and the eyes are protected by glasses. The oysters are dropped into tubs suspended from the waist.

THE WOMEN PEARL DIVERS OF JAPAN.

as it is turned. In the black-lipped shell (Margaritifera) the mother-of-pearl is of a greenish black color. In the shells of the true pearl-oysters the nacre is of a clear, delicate white, which has the sheen of floss silk faintly tinted with azure, exhibiting a beautiful play of color—a quality which makes these shells of great value in commerce.

Now it often happens that foreign substances such as sand grains, microscopic organisms of various kinds, parasitic worms, crabs, or sometimes even small fish are introduced by accident or otherwise inside the shell or in the tissues of the mollusk's soft body. In such cases, the animal sometimes begins to deposit a part of the material which goes to form the nacreous layer of the shell around or over these foreign objects, and as new material is added year after year in the form of layers, these concretions, which may at first be very tiny, grow to be of a considerable size. When this takes place in a shell with specially beautiful nacre, such as that of the pearl-oyster, the result may be an object of great beauty. In this strange way, pearls are produced.

Such being their origin, pearls may be formed in any kind of mollusk, bivalved or spiral. And just as the nacre of different kinds of shells differs, so the pearls themselves vary according to the shell which produces them. Thus the pearls of the common oyster, the scallop, and the giant clam are milky white and not very bright, while those of the sea mussel are usually black. The chank and the conch shells produce the pink pearls which are brought from the Bahamas and the West Indies. These pink pearls are also found in several kinds of fresh-water mussels, which are plentiful in some of the streams and lakes of America, Europe, China, and Japan. Most superb

made to produce the precious objects at will. We do not here refer to the manufacture of "artificial pearls" such as the so-called "Roman pearls," "Venetian pearls," etc., which are not pearls at all, but are made of glass and painted with fish-silver; rather what is referred to are the attempts to make the pearl oyster work for man and produce natural and true pearls in a reliable and methodical manner—in short a kind of "harnessing" the mollusk for the service of man.

It is well known that Linnæus, the "father of natural history," claimed that pearls could be obtained by piercing holes in the shell of an oyster with a fine auger, making a small wound, and afterward "parking" the animal for many years. But his suggestions do not seem to have been clearly understood, and no one has been able to pursue his method successfully. The Chinese, as is well known, have been specially successful in raising pearls by inserting grains of clay between the shell and the thin outer membrane which covers the soft body of the fresh-water mussel; but the best of these are of very inferior quality, and are valuable merely as curios.

At the International Fisheries Exhibition held in Berlin in 1880, some pearls were shown which had been cultivated in Germany. From looking at these, one could see that the plain relief might be covered with nacreous substance, but the result was of little value. Mr. Saville Kent, late naturalist to the government of Queensland and to that of western Australia, undertook the same experiment with the large pearl oyster, and a gentleman on Thursday Island tried inserting a shot through a hole in the shell.

The most important of such experiments are probably those of Dr. Louis Boutan of Paris, who succeeded some six years ago in producing pearls in the

laughed at him for "throwing his money into the sea." However, he persisted, making all sorts of experiments and changing his methods from time to time, relying on suggestions and advice from Prof. Mitsukuri and Dr. Kishinoue. At the end of four years of hard work, disappointment and renewed efforts, some results were obtained which seemed to promise success. In 1896, things had so far progressed that the experimental stage was a thing of the past, and the enterprise was put on a commercial basis. A patent for the new method was obtained from the government, and the cultivation of the pearl oyster on an extensive scale was begun at the island, Tatokujima, in the Bay of Ago, leased some time before for the purpose. At the end of 1898 the first, though small, crop of pearls was harvested and placed on the market. These have been given the name of "culture pearls" by Prof. Mitsukuri. Since then the enterprise has been steadily growing in every way, and the skill and experience obtained by handling millions of pearl oysters have enabled the establishment to maintain a constant improvement in the quality of the pearls produced.

THE PEARL-CULTURE FARM.

About a dozen miles south of the famous Shrine of Ise is the sheltered Bay of Ago, long famous for producing the best quality of pearls. It is a remarkably quiet body of water some six miles in length and three miles in breadth, with an average depth of ten fathoms, although it is over twenty fathoms deep near the entrance. The coast line is cut into with many deep and irregular indentations which, besides affording excellent shelter and ground for the pearl oyster, have the additional merit of making the scenery exceedingly picturesque. The fact that the "Kuroshiwo," the great "gulf stream" of the Pacific, sweeps near by,

is also undoubtedly an important factor in making this a favorite haunt of the precious mollusk.

Somewhat to one side of the middle of the bay toward the north is the small island of "Tatokujima," the center of Mikimoto's enterprise. When first taken possession of it was uninhabited, but now it supports a flourishing colony of several dozen families and many hundred individuals all connected in some capacity with the pearl-oyster culture. The sea bottom around the island was at first leased, the area being increased from time to time until finally in 1903 and also 1905 the government, recognizing the importance of the enterprise, granted the use of a very large portion of the bay, so that at the present day, the whole of the sea area leased by Mikimoto extends for 29 nautical miles.

The pearl oyster cultured on these grounds belong to the species (M. martensi) abundant in the Bay of Ago and found more or less in all parts of Japan. They closely resemble the Indian species found near Ceylon, famous for producing the finest pearls in the world. These mollusks live at depths not exceeding seven fathoms, and are anchored to rocks, stems of algæ, etc., by threads which the animals secrete.

The methods practised at Mikimoto's farm are as follows:

Every year during the months of July and August small pieces of rock and stone are placed in spots where the larvæ of the pearl oysters have been found to be most abundant. Soon small oyster spat are found attached to them. As this takes place in the shallow waters of not more than a few fathoms, they would die from cold, if left there during the winter; so together with the rocks to which they are anchored they are removed to deeper waters and carefully laid out in beds prepared for them. Here they lie until they reach their third year, when they are taken out of the sea and undergo an operation which leads to pearl formation. This consists chiefly in introducing into them the small pearls or round pieces of nacre which are to serve as the nuclei of pearls. The shells are then put back into the sea and left undisturbed for at least four years more. At the end of that time, they are taken out, and it is found that the animal has invested the inserted nucleus with many layers of nacre and has in fact produced a pearl.

Pearl culture as we have described it may seem to be very simple, but in reality it is by no means an easy work. Large mortality among the pearl oysters from various causes, the ejection of the inserted nuclei, the depredations of the oysters' enemies, uncertainties attendant upon long years of waiting, are some of the drawbacks which beset the industry. The most dreaded of all the evils is perhaps the invasion of the so-called "red current." This has been ascertained to be due to an immense accumulation of microscopic organisms causing a discoloration of the sea water. Wherever this appears it is followed, for some reason not yet well understood, by a wholesale destruction of marine organisms, and when it invades the pearl-culture grounds, it may undo in one day the work of years. Another unwelcome intruder of the culture ground is a sea weed called "Mirumo" (Codium), which if allowed to grow luxuriantly will cover up the pearl oysters and stop their growth or even kill them by smothering them, so to speak. Again the octopus plays sad havoc among the pearl oysters which it seems to consider a great delicacy. The starfish is another animal which especially enjoys a meal of pearl oysters.

THE WOMEN PEARL DIVERS OF JAPAN.

Every country has its own particular method of catching fish and shell fish, and so has Japan. Among the many different methods employed in Japan for pearl fishing none is more interesting than that employed by the women divers, who obtain the pearl oysters. Pearl fishing is conducted mainly by men divers in Australia and India and other countries, but in the region about Ago Bay in the province of Shima, the Bay of Gokasho in the province of Ise, as well as in other parts of the country, women are employed in diving. Still the general tendency nowadays is to engage men wherever possible. The women along the coast of the Bay of Ago and the Bay of Gokasho, when they reach thirteen or fourteen years, by which time they have completed a primary school education, go to sea and learn to dive. Thus they are trained more or less from childhood in their vocation. Their native towns and villages lie along the seashore. Hence it is but natural that they should all dive and swim almost from babyhood. They are in the water almost all the year round, except in the coldest season, from the end of December to the beginning of February. Yet even during this inclement season they sometimes dive for pearls. It goes without saying that the climate in these regions is almost always mild, and that snow is almost unknown in winter. These women divers wear a special dress. White underwear is worn, and the hair is twisted up into a hard knot. The eyes are protected by glasses to prevent the entrance of water. Tubs are suspended from the waist. A boat in command of a man is assigned to every five to ten women divers to carry them to and from the fishing grounds. When the divers arrive on the grounds they leap into the water at once, and begin to gather oysters at the bottom. The oysters are dropped into the tubs suspended from their waists. When these vessels are filled, the divers are raised to the surface and jump into the boats.

The Mikimoto pearl farms lie at a depth of from five to thirty fathoms, with an average of ten fathoms. The women dive to the bottom without any special apparatus, and retain their breath while they remain under the water. They stay under the surface from one to three minutes. When they are chilled they return to the shore, and warm themselves at fires built in huts especially for the purpose, and then return and resume their work. The women engaged in this work vary in age from thirteen to forty years. Women from twenty-five to thirty five make the best divers because of their physical strength and experience. The hours of labor vary with the seasons. In warm summer weather about six to eight hours constitute a day's work. In cold weather the divers cannot work more than from one to two hours. The wages paid range from ten cents to fifty cents a day. The highest ever paid is one dollar. Astonishing as it may seem, some of the women manage to save considerable money, largely because the cost of living is very low. Most of the young divers try to earn their marriage dower by diving. Even after marriage many of them support their families by diving. Skill in diving is a woman's greatest possession. Most of the pearl fisheries are situated in small inlets flanked with evergreens. The water is wonderfully clear. There is something indescribably picturesque in the aspect of divers plunging into the glassy water, and sending out ripples in all directions. Their curious whistle as they inhale and exhale on entering and leaving the water has something uncanny about it.

THE EXPANSION OF AIR BY HEAT.

SOME SIMPLE EXPERIMENTS.

If a bladder, partly filled with air and with its neck tied tightly, is laid on a hot stove, it will soon become filled completely, and it will burst with a loud report if it is heated very hot or has been nearly filled with air in the first place. As the same confined mass of air which only partly filled the bladder when cold fills it completely and "to the bursting point" when hot, this simple experiment gives a striking proof of the fact that air expands when its temperature is raised.

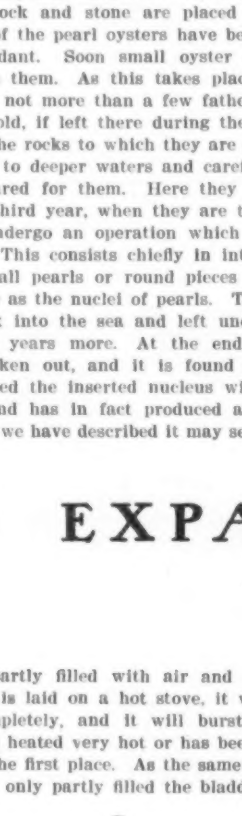


Fig. 1

The following experiment shows that even a slight increase of temperature produces an appreciable expansion. A glass tube, softened by heating in the flame of a spirit lamp or a Bunsen burner, is bent into the form shown in Fig. 1, and, when cold, is accurately fitted to a hole bored through the tightly fitting cork of a small bottle. A little colored water is poured into the tube, of which it fills the U-shaped portion which is shaded in the illustration, forming a water seal and preventing communication between the air in the bottle and the external atmosphere. If the bottle is clasped with the hand the level of the water rises in the branch *b* and sinks in the branch *a*, because the water is driven along the tube by the expansion of the confined air by the heat which it receives from the hand.

The appearance of vibration or "shimmering" which is observed over a hot stove, and over paving-stones exposed to the sun in summer, is caused by the ascent of air which is expanded, and consequently made lighter, by contact with the heated stove or stones. Spiral strips of stiff paper and more elaborate constructions containing inclined surfaces are often mounted on pivots over stones, where they are caused to rotate rapidly by these upward air currents.

The ascensional force of heated air is shown still more strikingly by the following experiment: Strips of tissue paper are pasted together to form a bell, which is hung over a tripod, as shown in Fig. 2. A single upright rod may be used instead of the tripod, but the rod should carry at its top a rather large disk in order to keep the mouth of the bell open. If a large spirit lamp or, preferably, a little cotton wool placed in a cup and saturated with alcohol, is set beneath the mouth of the bell and lighted, the paper bell will soon become inflated with hot air and will rise to the ceiling. The bell is, in fact, a hot air or fire balloon, the oldest of all balloons, which was invented by the brothers Montgolfier more than a century ago. The Montgolfier balloon was made of paper, yet these pioneer aeronauts dared to intrust their lives to it, and thus made the first balloon ascension, from Lyons, France, in 1783. The balloon was filled with smoke produced by burning wet straw and wool. The Montgolfiers thought, until they were convinced of their error by men better versed in science that this smoke possessed electrical properties which increased its lifting power.—Kosmos.

A SIMPLE METHOD OF ELECTROPLATING.

At a meeting of the Royal Society of Arts on February 2nd, a paper by Mr. A. Rosenberg was read upon an improved method of electroplating. Mr. Rosenberg dispenses altogether with the plating bath and all external sources of electricity. The plating is carried out simply by rubbing on a powder moistened with water. The process is really a refinement of the old contact method. It will be remembered that in this process a piece of metal which it is desired to plate upon is immersed in an electrolyte, for example, one containing a silver solution. In contact with this metal a more electropositive one is placed, also dipping into the electrolyte. This metal, usually zinc, passes into

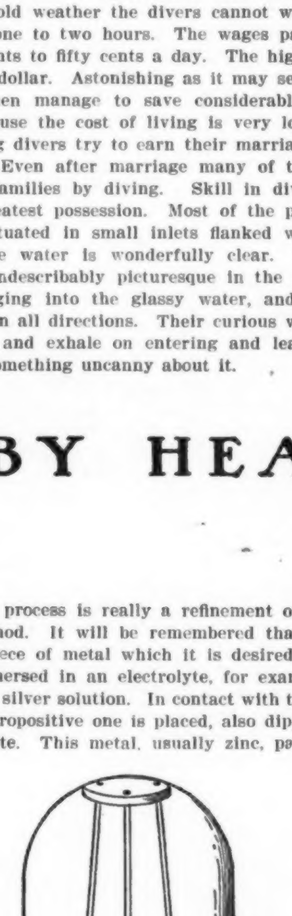


Fig. 2

solution, and an electric current thereby is generated. The silver is then plated-out upon the less electro-positive metal.

Mr. Rosenberg employs his electro-positive metal in the form of a fine powder, and generally uses magnesium. This is mixed with a metallic salt or with the powdered metal it is desired to plate-out, and ammonium sulphate or other ammonium salt. In order to plate a piece of metal the powder is moistened with water and rubbed over its surface by means of a piece of rag or a brush. By this means adherent and bright deposits are obtained in about one minute, the thickness of the deposit depending upon the time employed and the quantity of powder used.

The magnesium, being strongly electro-positive, reacts with the moist electrolyte, and goes into solution, causing the metal to be plated-out upon the metallic

surface which is being rubbed. In other words, each particle of the powdered magnesium may be said to function as a minute anode. One of the difficulties in electroplating is to plate a substance upon itself. It is easy enough to give it almost any thickness of deposit; but if the spoon is once withdrawn from the bath and used, it cannot be plated further without first stripping off the old deposit. Mr. Rosenberg claims that with his process this difficulty does not occur.

Another great difficulty in electroplating is the cleansing of the article to be plated; the least trace of grease, even that produced by handling, for example, will prevent an even and adherent deposit. Consequently, articles have, as a rule, to be chemically and mechanically cleaned before being put into the plating bath. With the powder, "Galvanit," of Mr. Rosenberg this is not necessary, because the act of rubbing the powder carries out its own cleansing.

The author's object has been to produce a household method of plating. Thus, when the tinning of saucepans is worn out, the householder has only to polish the inside with the moist "tin Galvanit" to retin the saucepan. Spoons from which the silver-plating is partly worn can be re-plated. The "nickel Galvanit" can be used for bicycles and so on. Mr. Rosenberg demonstrated the process before the meeting by plating an iron tube with cadmium, a copper tube with nickel, a penny with silver, and a brass tube with tin.

"Galvanit" can also be used for nickel-facing electrotypes. The process is certainly ingenious, and will no doubt be found useful for small work, but it is hardly likely to enter into competition with ordinary electroplating for large work or for irregular articles. Nor is it likely to be employed in cases where heavy coatings of metal are required, because it would not be an easy matter to rub on sufficiently evenly to obtain uniform and thick deposits.—Nature.

A NOVEL HYDROCARBON ENGINE.

A VARIABLE-STROKE GASOLINE MOTOR FOR AUTOMOBILES.

EVEN the best constructed gasoline motor is greatly lacking in the elasticity that characterizes the steam engine. To obtain the highest efficiency with a gasoline motor of ordinary construction the compression pressure and piston speed must be equally considered. All gasoline automobiles are provided with a transmission gear for varying the speed, by means of which a certain variation of the speed rates of transmission (Webersetzungsverhältnisses) between the speed of rotation of the motor crankshaft and the driving wheels is secured.

This disadvantage does not attach to the steam engine, because the turning moment may be increased or diminished by the mere regulation of the pressure of the steam upon the piston. There have been numerous attempts at the construction of an internal combustion motor for automobiles in which the necessary variation of the ratio between the crankshaft speed and that of the axle of the driving wheels could be attained without the employment of the usual transmission gear. Most of these have been unsuccessful, but a new type of motor has recently been brought out in which the piston-stroke may be varied while the volume of gas expelled by the piston bears constantly the same ratio to the entire working capacity (Arbeits-Kapazität) of the cylinder; i. e., the compression remains constantly about the same and the difference in compression as between the longest and the shortest stroke is only about 5 per cent. This motor is the invention of two English engineers, Messrs. Gill and Aveling, and they claim that it offers a perfect solution of the direct-drive problem upon gasoline automobiles. The motor, however, has not yet been tried in practical use on an automobile.

The accompanying illustrations reveal clearly that the principles of the motor, cylinder, combustion-chamber, inlet and exhaust valves, water-cooling and many other details, are identical with those of the ordinary gasoline motor; but the crankshaft ends of the connecting rods *A* are not fastened to the crankshaft. Instead they are attached to pins *B*, which fit between the forked ends of other connecting rods *H* that extend horizontally to the crankshaft.

Each pin *B* is fastened radially by means of a pair of connecting rods *C*, and the motion of the pin is confined to a path determined by a quadrant placed above the crankshaft. The shaft *D* is provided with square sections through which pass the threaded rods *F*. By turning these, shaft *D* can be raised or lowered in the sector *E*. Rods *F* are turned by means of a longitudinal shaft and bevel gears *G* placed above the motor. In a four-cylinder motor the shaft extends the entire length of the motor.

The 50-horse-power motor shown has four cylinders, each of 125 millimeters bore. The stroke varies between a minimum of 50 millimeters and a maximum of 188 millimeters. It gives about 50 horse-power.

The three diagrams give the relative positions of the connecting rods *A H* and the tie rod *C* for the strokes of 50, 112, and 188 millimeters (2, 4½, and 7½ inches).

The full lines represent the position of the rods when the piston is at the highest point of the stroke, and the dotted lines their position at the lowest point of the stroke, while the three rectangles of the figures indicate the volumes of gas corresponding to the three lengths of piston stroke.

The diagrams show still another thing: If we take for a standard of comparison the upper piston edge in the left of the three drawings, it will be seen that in proportion as the stroke increases, the piston, in its highest position, is at a lower point in the cylinder. The increase in size of the explosion chamber thus effected is such that the relation of the volume of the stroke to the total volume always remains the same.

At first glance the construction of this motor seems somewhat complicated, and in fact the cost of construction must be considerably higher than for the ordinary gasoline motor.

In case, however, the motor is able to fulfill the claims made for it, this increased cost would be compensated for by dispensing with the transmission gear. Such a motor also should be very economical in fuel consumption, and the mechanical efficiency remains throughout the whole scale in constant ratio to the length of stroke. Another advantage of this motor is that the lateral pressure reaction on the cylinder walls is reduced to a minimum. When the motor has been mounted in the car and the carbureter has been properly adjusted for the atmospheric condition, then every further variation of the number of revolutions or of the horse-power will be effected merely by the variation of the length of stroke; the throttle valve will then be used only when the motor with the shortest piston stroke develops more power or speed than the condition of the road demands at the moment.

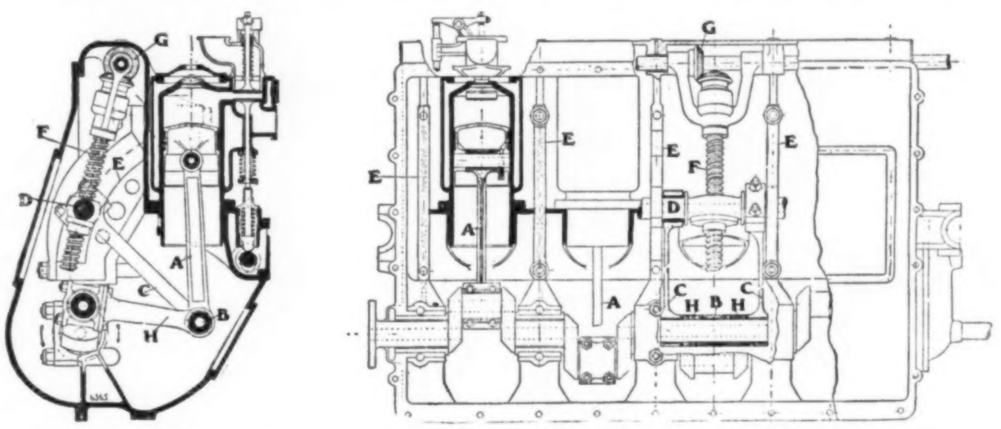


FIG. 1.—CONSTRUCTION DIAGRAM OF A 50-HORSE-POWER 4-CYLINDER MOTOR WITH VARIABLE PISTON STROKE.

The only things which may still be needed to make the motor practically useful would be an automatic starting device and a displaceable cam shaft, by means of which the motor might be made reversible. In this way the transmission gear could be entirely dispensed with.

Mr. Gill has already constructed a model and made an interesting series of experiments.

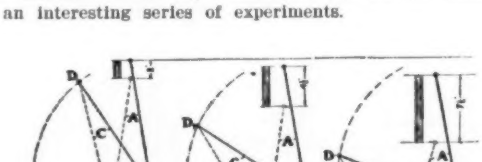


FIG. 2.—DIAGRAM SHOWING THE POSITION OF THE PARTS WITH A STROKE OF 50, 112 OR 188 MILLIMETERS.

The cylinder diameter in this one-cylinder model (Fig. 1) is 75 millimeters, and the piston stroke can be varied between 25 and 88 millimeters. In the illustration the cover is removed, so that the parts in operation are visible. In spite of its apparent complexity, every part of the motor can be easily reached as soon as the cover, which forms a part of the crank-case, is removed.

There are in the world, we are told by the late William Kingdon Clifford, three classes of persons: in the first place, scientific thinkers; secondly, persons who are engaged in work upon what are called scientific subjects, but who in general do not, and are not expected to, think about these subjects in a scientific manner; and lastly those whose work and thoughts are unscientific. Scientific thought is not determined by the subject thought of. The subject of science is the universe, its limitations those of the human mind. When the captain of a ship finds its position by means of observations with the sextant, or when an engineer constructs a dynamo with the aid of a drawing and data known to be correct, he does not engage in scientific thought, although he makes use of experience previously collected. When the computer in the office of the Nautical Almanac computes an eclipse of the moon, foretelling it to a second of time several years before the event, he is not engaged in scientific thought, but is making use of technical skill. When, on the other hand, Adams and Leverrier, computing the positions of the planet Uranus, found them not verified in fact, but by the assumption of a new hypothesis, were able to discover the planet Neptune, they were engaged in scientific thought of a high order. The collection of facts, as one collects postage stamps or coins, does not constitute science. In order to have science the facts must be fitted into a definite system, in accordance with a classification on the basis of what we call laws. It is a prerequisite for the existence of any science whatever that we admit that nature is subject to uniformity, that is, that similar circumstances of similar things will be followed by similar results. The belief that the order of nature is reasonable, that is, that there is a correspondence between her ways and our thoughts, and that this correspondence can be found out, is scientific faith. The method of the inductive sciences, those that concern the facts of nature, is first to observe a class of seemingly related facts in order to find out what they have in common, then if possible to form some hypothesis as to their relation, then to compare the different cases with the hypothesis in order to see whether it is justified. When this process has been successfully carried out, we are able to predict what will occur in given circumstances, although these circumstances have not occurred. This is what we mean by discovering a law of nature, namely, finding a common property of a class of phenomena, such that under all circumstances the phenomena which will ensue can be described. That is what constitutes the difference between scientific and technical thought. Technical knowledge enables us to deal with cases that have occurred before, while scientific knowledge enables us to deal with what has not occurred before.

Mr. Fisher, of the United States Geological Survey, says: "Few coals less than 14 inches thick are mined in a commercial way in the United States, but beds only 8 inches thick are mined commercially abroad. The first English Royal Commission on coal supplies in 1871, fixed 12 inches as the minimum workable thickness; however, many separate beds 8 and 10 inches thick are now worked commercially in England."

THE ORIGIN OF THE LUNAR CRATERS.*

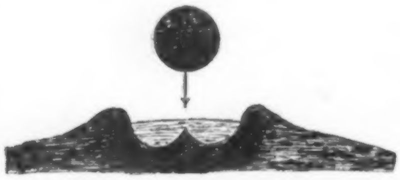
A CONSIDERATION OF THE IMPACT THEORY.

BY T. J. J. SEE.

In a paper just published in the Astronomische Nachrichten, No. 4367, November, 1909, the writer has treated of the problem of the obliquities of the planets, from the point of view of the capture theory, and has shown that Jupiter's small obliquity has been produced by the capture and absorption by the giant planet of vast quantities of satellites moving about the sun in planes nearly coinciding with the plane of the planet's orbit. It is shown by calculation that if the mass of Saturn were increased by this process of capture till it became equal to that of Jupiter, the obliquity of Saturn would become as small as that of Jupiter; whence it is inferred that Jupiter's obliquity was once large and afterward gradually destroyed by the growth of his mass from the capture of satellites moving near the plane of his orbit. This theory of the planetary obliquities is applied to the other planets of the solar system, and the facts are shown to be in good agreement with the theory.

The origin of the lunar craters has long been a debated question in astronomy, but the traditional opinion dating from the time of Galileo is that they are volcanic; and this view is still held by leading investigators, such as Puiseux, of the Paris Observatory, and Prof. Ebert, of Munich. The theory that the lunar craters are volcanic seems to have originated with Hooke, 1667, and was generally held till the time of Humboldt. About the middle of the nineteenth century, however, several investigators, but especially Humboldt himself, and Schmidt, of Athens, became doubtful of the volcanic origin of these circular mountains, mainly because the inner parts of the craters were found to be depressions, with the central peaks below the average level of the lunar surface. A tentative theory that the craters might be due to impact was outlined by Proctor in 1873, mentioned by Newcomb as a curiosity in 1878, and more fully worked out by the geologist G. K. Gilbert, in 1892; but it has never been accepted either by geologists or astronomers.

After a careful examination of all the evidence, I am satisfied that the impact theory is correct, and that the current volcanic theory is not well founded. It happens that the impact theory brings the phenomena of the lunar surface into harmony with the capture theory of satellites and of the obliquities of the planets; and it will, therefore, contribute to our understanding of the phenomena of the solar system. If Jupiter's small obliquity has been produced by the capture and absorption of satellites, the evidence of such collisions, preserved by the indentations in the moon's face, becomes an important chain in the reasoning for establishing the processes involved in the formation of the planets and satellites. The present discussion is restricted to a brief summary, but the reader who is interested in the subject should be referred to a paper on the cause of the variability of satellites recently communicated by the writer to the Astronomische Nachrichten, and to Gilbert's important paper of 1892. (Bulletin of the Philosophical Society of Washington, vol. xii.)



HOW A LUNAR CRATER IS MADE BY A FALLING SATELLITE.

In connection with the formation of these craters, Capt. A. W. Dodd, U. S. N., has made several valuable suggestions resulting from his large experience in various kinds of target practice. He tells me that when the resisting surface is not too hard, experiments with projectiles indicate that the crater will have about three times the diameter of the impinging shell. Accordingly for the lunar surface, with typical craters about sixty miles across, the impinging satellites probably had a diameter of some twenty miles, about like the planet Eros, or the smaller asteroids.

If we wish to calculate the temperature of the falling mass after collision, it is easy to approximate it by the formula for the mechanical equivalent of heat:

$$Q = \tfrac{1}{2}mv^2 = \frac{v^2}{2 \times 9.81 \times 425} = \frac{v^2}{8339} \text{ calories.}$$

We find that for a mass of a kilogramme, moving with the parabolic velocity of the lunar surface, 2.37 kilometers per second, the result will be:

$$\frac{[2370]^2}{8339} = 673 \text{ calories.}$$

If the specific heat of a stony satellite be approximately 0.2, as in the case of terrestrial stone, the effect of the total heat of collision would be to raise it to a temperature of 3365 degrees centigrade. But some heat is transferred to the moon's surface and a considerable part of the energy is expended in sinking a crater and throwing up a wall about it. Notwithstanding this division of the energy, it is clear that many of the satellites colliding with the moon would be more or less melted and vaporized. As our moon has no atmosphere, the dust arising from such a conflagration would rapidly fall as metallic and lithic rain, and tend to cover up the ancient craters. The condition of things thus predicted from mechanical theory is strikingly verified by observation of the lunar surface.

INDENTATIONS IN A LEADEN DISK MADE BY BULLETS FIRED BY CAPT. A. W. DODD, U. S. N., AT MARE ISLAND.

It is found that the impact theory explains the following facts:

1. Both large and small craters, and their superposition over one another, some being older and others newer, as the case may be.

2. The frequent occurrence of small craters on the rims of large ones, where they would scarcely arise from eruptive causes.

3. The existence of craters in perfectly smooth plains, as well as in rough and broken regions; and the unequal density of the craters in different parts of the lunar surface. Terrestrial volcanoes generally follow the mountain ranges along the seacoasts. On the moon the craters are scattered indiscriminately, except that they are rare in maria, for reasons which will hereafter appear.

4. The greater steepness of the inner walls, and the great diameters of the larger craters, which could not well be explained by volcanic forces. If it be thought that more larger craters ought to be elliptical than are observed, it may be recalled that, even if the first contact with the moon produced such an outline, the impact of a large satellite would generate enough heat and underlying flow to force out the walls about symmetrically all around, and the final figure would be circular like the globular figure of the satellite. Thus craters which are, say, ten times as wide as they are deep, ought to be almost circular; while smaller craters would be more irregular and elliptical, as found by observation. This is because the forcing out of the material beneath small craters is less effective than in the case of large craters, and they retain more nearly their original shape of first contact.

5. The very flat-bottomed craters, noticed in such regions as Mare Nubium, are due to the filling up of deeper and more irregular craters with cosmical dust, or by melted material, which has assumed a level surface. This has at length become so deep as to leave only the walls visible about a level central area, while the central peaks have been nearly or entirely covered up.

6. In many cases the lunar photographs show that even the walls are practically covered up; for they can now be traced with difficulty, and merely as a faint outline. The walls are covered up, especially in the so-called maria. So far as one can see, two and only two, explanations of these so-called "ghost" craters are possible: 1. The deposit of cosmical dust from the heavens, and from the conflagrations arising in the impact of satellites. 2. The partial melting down of the walls by the conflagrations, which produced the maria, so that only an outline of the original crater walls can be traced. The fact that the "ghost" craters occur chiefly in the level maria supports the conflagration and melting hypothesis, and this certainly is one of the leading causes. But since the earlier craters away from the maria also show the effects of age, as if tending to become obliterated by falling dust, this latter cause also is at work. Moreover, the two causes necessarily are related. Together they explain the ageing of the craters in the rough regions far from the maria, as well as the buried or "ghost" craters in the maria themselves.

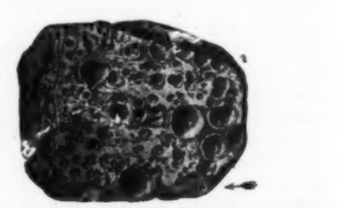
7. This shows that many craters have not only been obscured and partly blotted out by the falling dust, but also that a countless number of these objects have been permanently buried by the process of deposit and conflagration. The so-called seas are areas once made level by melting, in which few recent craters have been formed. The seas of the moon appear to be singularly level, and this can only point to terrible impacts at some time in the past, by which these whole areas were so fused that pretty much all inequalities of level disappeared. They have since been covered with a layer of cosmic dust, but have suffered relatively few large indentations. They generally appear dark, because the surface is nearly level, and the sun's light when reflected is but little scattered and seldom so directed that the beam from any considerable part of the surface passes near the eye of the observer.

8. If this view be correct, it also indicates that the whole moon was formed by accretion, and that the surface never did experience true eruptive phenomena, such as we observe on the earth.

9. The interior of the lunar craters is generally below the level of the surrounding normal surface, and this cannot well be explained except by impact. Volcanic eruptions could not well produce depressions of the crater basins.

"The bottoms of many of the craters are very deeply depressed below the general surface of the moon, the internal depth being often twice or three times the external height." (Herschel, "Outlines of Astronomy," sec. 430.)

This remark of Sir John Herschel's shows that decided depression of the basins is common to all craters, both those with rims and those without. It is almost impossible for volcanic forces to produce such a result. One or two Hawaiian volcanoes are the only depressed craters on the earth, and they are recognized to be exceptions to the general rule of elevation characteristic of our planet.



HOW SOFT MUD IS INDENTED BY FALLING RAINDROPS.

10. It is evident that the craters have not been produced by the removal of material from the center and the piling of it up to make the surrounding walls; for in probably three-fourths of the cases, as Prof. H. Ebert has shown, it is easily proved by calculation that the volume of the excavation exceeds the volume of the material contained in the wall. This remarkable volume relationship would be explained if the matter beneath the crater were compressed by the force of impact, and only a part of it and of the falling satellite forced out to form the surrounding walls.

11. The shorter streaks radiating from such centers as Copernicus and Aristarchus are easily explained. It is sufficient to suppose that the collision was so forceful that matter was scattered far out in all directions, and perhaps heated to fusion in the process; yet, as the moon has no oxygen, it did not burn and blacken as meteoric stones do in falling on

* Presented to the Astronomical Society of the Pacific, November 28th 1909.

the earth, but simply took on a fused and glassy aspect, which, by reflection, gives the brightness of the shorter streaks radiating from Tycho and its associates. This explanation was given by Mr. Würdemann, of Washington, D. C., many years ago, in a letter to Dr. B. A. Gould, but it seems to be but little known to astronomers.

12. The long rays from craters such as Tycho are similar optical effects of glassy material falling on walls of craters lying nearly in a straight line, and radiating from this center. This is shown by the photographs. Any crater which had matter ejected from it radially, in the process of formation, will have a system of rays, due to the effect of the sunlight on the higher elements of the surface traversed by the rays running from the crater as a center.

13. As the moon's force of gravity is feeble, the vapor and metallic and lithic rain due to impact might be carried hundreds of miles, and these streaks due to material falling on corrugations and ridges might extend out from the craters for a considerable distance, and sometimes appear to be prolonged by coincidence with other crater walls or ridges.

14. The craters, which are simple depressions without sensible walls, are to be explained by the comparative looseness of the material of the moon's surface layers, which allows the mass to yield downward without throwing up much of a wall about the depression produced.

the progressive falling of cosmical dust, in a celestial world devoid of rain or other meteorological disturbance of any kind.

20. At zero degree centigrade the maximum molecular velocities of the atmospheric gases are found by Dr. Johnstone Stoney to be as follows: Oxygen, 1.8 miles; nitrogen, 2.0; water vapor, 2.5; helium, 5.2; hydrogen, 7.4. These values usually decrease with the fall of temperature, but the modification thus arising is not very considerable for small changes.

21. Now, at the surface of the moon, the parabolic velocity is 1.5 miles (2.41 kilometers, cf. A. N. 3992, p. 136), and, therefore, none of these atmospheric gases can be retained. For, although we do not know the moon's temperature very accurately, it would seem that during the lunar night, it must approach the absolute zero, while during the day it cannot well exceed the boiling-point of water. Accordingly, the above values are not sensibly altered by the admissible variations of temperature.

22. Observations on the refractions of stars occultated by the moon prove that if any sensible atmosphere exists at the lunar surface, it does not exceed 1-5000th part of the density of the terrestrial atmosphere. We may, therefore, conclude that no sensible atmosphere has ever existed upon the moon, either before or since the capture by the earth; but that the vapors there arising have congealed into dust or constantly escaped into space.

rise to a temperature that would produce fusion of rock. Even when radio-active substances are considered, the conclusion is the same—namely, that in the slow and almost insensible development of the moon by accretion, enough heat to produce general fusion could not have arisen.

Accordingly we may dismiss the old volcanic theory once for all as false and misleading; and may look upon our satellite as a battered planet, which presents to us the most lasting and convincing evidence of the processes of capture and accretion by which the heavenly bodies are formed.

The strength of the present argument regarding the origin of the lunar craters does not rest on one class of phenomena alone, but on several distinct classes of phenomena, which are all harmonized among themselves and brought into accord with the necessary processes of planetary growth. Since worlds form in nebulæ, it follows that impacts will necessarily occur and the moon's face shows the size of these masses by their imprints, which thus throw an unexpected light upon the state of the solar system in the past.

The variability of the satellites of Jupiter and Saturn, photometrically investigated by Guthnick in A. N. 4023 and A. N. 4098, indicates that they, too, have maria covering their surfaces, due to collisions, as in the case of the moon. For, as observed from a distance, the moon also would be variable, according

THE MOON SEVEN DAYS OLD, SHOWING THE GREAT NUMBER OF CRATERS DOTTING THE SURFACE OF THE SATELLITE.

Photographed by Ritchie at Yerkes Observatory.

MARE SERENITATIS, MARE TRANQUILITATIS AND SURROUNDINGS, SHOWING GHOST CRATERS BURIED BY CONFLAGRATION AND DEPOSIT.

Photograph by Ritchie at Yerkes Observatory.

15. The clefts are paths cut by glancing satellites, which thus leave a straight or curved line, according to the nature of the surface and the resistance and rebound. Photographs confirm this origin of the clefts, and show that they are not cracks, but actual cuts, sometimes more than a hundred miles in length.

16. Rills are cracks or offsets along walls of craters which often are more or less hidden by later deposits. They pursue in some cases an irregular course, and often may be due to settlement of loose material, as in landslides on the earth.

17. Changes in the aspects of a crater due to caving in, settlement, etc., are always possible; but to be entirely certain that the change is real, the illumination has to be exactly the same at the two epochs, which is seldom possible. If the suspected changes are real, photography will eventually establish this fact.

18. The covering up of ancient cities on the earth is due to deposits of waste, rubbish and dust traceable to meteorological causes connected with the atmosphere, such as sand borne by the wind from the desert, etc. On the moon, however, there is no atmosphere sufficiently dense to carry dust, and it must, therefore, be scattered by impacts and by direct descent from celestial space. The fact that the older craters are visibly covered up, is a tangible proof of the part played by cosmical dust in the course of ages.

19. The different degrees of obliteration shown by the various lunar craters is an impressive witness to

23. The cosmical dust that falls upon the moon, therefore encounters no atmospheric resistance, but plunges headlong against the lunar surface. Any vapor due to the force of collision quickly cools and is, if it condenses into solid particles, precipitated as dust, and nowhere amounts to a permanent cloud. If it remains true gas, the molecules gradually escape into space.

24. If now we compare the lunar photographs with the accompanying imprints made by raindrops, and by bullets fired into a leaden disk as a target, we shall notice the most remarkable similarity in the two effects. The raindrops, however, are all fluid, and leave only saucer-shaped imprints, and no central peaks; whereas the leaden bullets and stony satellites indenting the lunar surface would necessarily leave central peaks, in accordance with observations. Thus the moon's surface can be nothing but fragments of rock filled with finer dust; and it is evident that it has never been molten as a whole and has never shown true volcanic activity, as known upon the earth.

The last conclusion is confirmed from another point of view by an exact calculation given in A. N. 4053, p. 345, showing that the total gravitational heat of condensation of the matter of the moon would raise an equal mass of water through only 408 degrees centigrade. It is there pointed out (p. 348) that the development of such a small amount of heat, in the course of long ages, would not at any time give

to the extent of the maria on the side toward the sun. Lastly, the mathematical argument regarding the capture of the satellites and the moon is confirmed by Schroeter's observations, 1789-1793, showing that the planet Venus rotates in 23 hours 21 minutes. For, if Venus has that period, the earth never could have rotated faster than at present, and the moon necessarily would be a captured planet. There is found also to be a theoretical reason why Venus ought to rotate faster than the earth, so that the capture of the moon is confirmed both by the observations of Venus and by mathematical theory, and the origin of the lunar craters by impact is a necessary corollary to the capture theory of satellites.

U. S. Naval Observatory, Mare Island, Cal.

In a patent recently issued to Dr. C. P. Steinmetz, a description is given of a machine having interpoles without winding which operates sparklessly. The armature of the machine is of the closed-coil type provided with both a commutator and collector rings. The arrangement for operation is such that the m.m.f. of the current entering by way of the collector rings is greater than that leaving by way of the commutator, and the excess m.m.f. serves for exciting the interpoles to the extent required for sparkless operation. This result is obtained when the machine receives all of its power over the collector rings, and delivers only a part over the commutator, the remainder being utilized mechanically at the pulley.

CHEMISTRY IN THE LAST FORTY YEARS.*

A BRIEF SKETCH OF ITS REMARKABLE DEVELOPMENT.

BY W. NERNST.

ALTHOUGH in principle physics and chemistry follow the same methods and look toward a common end, an end which, as Helmholtz has so aptly described it for physics, is "To assert by the logical forms of laws our intellectual mastery over nature, at first a stranger to us," nevertheless the diversity of the problems and facilities has in practice necessitated a separation of the two branches. Consequently the energies of the physicist and chemist have been expended almost entirely on special problems in their own fields of research, and as a result a large boundary region between the two sciences remained neglected for a long time. Only in the period of time which this sketch covers has there been any lively interest in physical and theoretical chemistry.

No one will deny that, as far as any theoretical mastery of matter is concerned, physics has not for a long time made nor is even now making any advances. Why this can not be otherwise is easy to understand. The physicist often needs relatively only a very small amount of material to work on to derive immediately the fundamental theoretical laws of the subject which he is investigating. For example, it is only necessary to know the density of atmospheric air at a single temperature and a single pressure to develop physico-mathematically by the sole aid of the gas laws and the principles of the theory of heat the rule of sound vibration, and from that the fundamental principles of acoustics generally. How different and how much more difficult are the problems which confront the chemist when he attacks the study of atmospheric air, whether he attempts to determine its composition down to the last particle or whether he investigates the remarkable and complex equilibria which obtain at high temperatures.

Chemistry to-day can boast of a set of theoretical principles that do not suffer in comparison with those of physics. What a mass of experimental material is set forth in the table of atomic weights. What quantitative facts can the man of science draw forth from its figures, such as composition, specific heat, vapor density, lowering of the freezing point, and the like of innumerable substances. What can he not forecast, by the aid of general analogy, in the way of physical and chemical properties of many other kinds when he calls to his aid that happy artifice, the periodic classification. The very fact that such an abundance of material has been brought together necessarily increases many times its importance after it has once been successfully classified.

The theory of the constitution of organic combinations furnishes a good example of this fact. In a short time, when the organic compounds gathered together in the new edition of Beilstein's handbook, which this society has under preparation, are published, we shall, I have been told by the editor, be confronted by more than a hundred thousand structural formulæ. It is by the aid of this theory of organic constitution that a great part of these combinations have been worked out, and it is only by its aid that it has been possible to describe and classify this stupendous amount of material. And if one finally considers all the information the initiated can read out of the structural formulæ and considers the mass of experimental data that often had to be obtained to establish even one of them, he realizes that in the quantity of experimental facts logically construed and classified, the doctrine of the constitution of organic combinations stands at the head of all theories that the human mind has conceived.

Another effect of the development of chemistry from the theoretical point of view is that already in a great many cases theoretical and experimental work can hardly be distinguished, so impregnated with theory have most of the branches of chemistry become. Consequently, it is my task to-day to give not a general view of the whole of theoretical chemistry, but merely of that part which may be called physical.

In the first part of this sketch the relations between physical properties and chemical constitution will be touched on, a subject which formed the principal field of research for physico-chemical work in the latter half of the period we are considering. The description of this work will be very much facilitated by an adherence to a systematic mode of classification, according to which the properties of substances are divided into three groups.

There is, first, the measurement of those accessible quantities which render possible the immediate deduction of the values for the molecular weights, and which may be briefly designated as molar properties. Among these, as Avogadro has shown, the vapor density deserves a place in the first rank, but it has been left for the new epoch, by the aid of the direct and indirect methods of measuring osmotic pressure, to throw an equal light on the molecular weight of dissolved substances. In the determination of the molecular weight of liquids the value of the temperature coefficient of surface tension has been of the greatest assistance; the heat of vaporization, the critical constants, the curves of vapor tension, and a series of other values, also furnish more or less sure means to the same end.

All of these methods, with complete accord, lead to the conclusion that most substances, for instance the saturated hydrocarbons, possess the same molecular weight in the liquid state as in the gaseous condition, but that a number of substances, like the alcohols and especially water, are more or less highly polymerized in the liquid condition. But what is the degree of polymerization in each particular case? What equilibrium is established in these pure liquids? These interesting questions unfortunately still evade any exact or quantitative solution.

As the most important results of these new methods of determining molecular weights, especially of the osmotic method, we may mention first the ingenious theory of the existence of colloidal solutions as an intermediate stage between true solutions and mechanical suspensions, and then the more definite conception of the ion to which we shall return later.

A second series of properties are those designated under the name of additive properties. Any such property of a combination is the resultant sum of the properties of its constituents. To all appearances this is a very simple rule, but at the same time it is impossible to form any idea from it as to the size and structure of the molecule. Among these properties we may note, besides the molecular volumes of liquid organic compounds, molecular refraction, magnetic rotation, heat of combustion, and the critical coefficient.

A third series of properties depends not only on the nature of the atoms which exist in the molecule, but also on their arrangement in the molecular structure; accordingly they are designated constitutive properties. Thus the molecular refraction of hydocarbons depends not only on the number of hydrogen and carbon atoms present, but also on the existence or nonexistence of multiple bonds between the carbon atoms.

From this we derive a very important result; we may attribute to the double bond a determinate amount of refraction and take into account with a high degree of approximation the influence of its constitution, by a return to the additive method.

Frequently certain properties appear only with a particular grouping of atoms. In such case it is a qualitative rule of the highest value that, inversely, from the appearance of these properties we can predicate the existence of these definite forms of combination. The classic example of this type is afforded by the power of optical rotation in carbon compounds, which is dependent on the existence of one or more asymmetric carbon atoms (or similar asymmetric structures) in the molecule.

In the same way in these organic compounds one can discover from the appearance of color, or more exactly, from the appearance of certain characteristic absorption bands, as well as of fluorescence, the existence of particular groupings in the molecule. To this same category of properties belongs also, in the largest sense, electrolytic conductivity, which indicates the existence of free ions—that is to say, the combination of elements or radicles with electrons; and lastly, the appearance of the maximum value of 5.3 for the ratio of the specific heats of a gas is, according to the kinetic theory of gases, an indication of a monatomic state, a conclusion which, as is generally known, was first applied to a mercury vapor, and which in recent times has been of inestimable service in the determination of the atomic weights of the argon group of elements.

In the last analysis all these properties are probably constitutive also, and their interpretation as either purely molar or purely additive is only a more or less close approximation. Often, even in the regions which have already been cleared up to a great extent by the additive method, great difficulties have appeared upon a more careful investigation. I should like, therefore, all the more to place before you a special case where the theory seems to reach the greatest exactitude.

We have succeeded in reducing to exact terms the gas densities which for a long time afforded the only means of molecular weight determination. On account of the variation from the laws of perfect gases, which all actual gases show, it was natural that a method of approximation should be developed. In our epoch, however, we have learned with the help of van der Waals's equation, particularly by using compressibility, to reduce all gases to the ideal gaseous state and thence to deduce the exact relative values of molecular weights.

From these results, two ends have been attained: First, it has been proved that the most important of the theoretical laws that we possess, Avogadro's rule, appears to be an infinitely exact natural law; and second, a new method, purely physical, of determining atomic weights has been acquired which can stand comparison in exactness with the methods of analytical chemistry, but which is limited naturally to the cases where the density of compressibility of a chemically pure gas can be determined.

The problem, however, of reconciling experience and theory in the case of some other physical properties, as successfully as in this example, seems still far from solution. In general the exactness and consequently the reliability of theoretical treatment have been more striking in connection with the theory of corresponding states which we shall now take up.

In the theoretical consideration of natural processes, it has generally been considered necessary to take account only of very small variations of the system under observation; a variation of any extent caused so many complex accessory phenomena that it was possible for the mind's eye to follow them. Thus in theoretical physics we see the quintessence of nearly all theories represented by a differential equation, that is to say, by a mathematical formula which has to do with only infinitely small variations. The establishment of a differential equation (assuming, of course, that it can be solved) has a symptomatic significance in a science, since its employment proves that the region of corresponding phenomena has been carefully considered. It was, however, by a rare and fortunate chance that the law of mass action was established in chemistry some forty years ago.

I recall very vividly the great surprise I experienced when for the first time a differential equation appeared to me in the study of the speed of reaction of the saponification of ethers, especially when I discovered how beautifully the integral of this equation was confirmed by the facts. How many inconsistencies, how many irregularities, and how many values depending on all sorts of conditions appear at first glance in chemical phenomena! Nevertheless the law of mass action shows us that, if we disregard the secondary phenomena of supersaturation and the like, if we maintain a constant temperature, and if we consider a chemically homogeneous system, we will have to deal with phenomena very clearly defined and calculable with mathematical precision.

The law of mass action furnishes at the same time the law for static and kinetic chemistry. It gives us the outlines not only for the experimental investigation of chemical equilibrium but for the speed of chemical reaction. Therefore I can cite as the most important result of the last forty years in this field the fact that not only are we in possession of the laws of chemical equilibrium and the speed of reaction, but above all we can classify a great many experimental facts as logically following the law of mass action. This law, as I have stated, is of the most general application, but experience shows us that general theories are not very profitable. Accurate results are never obtained except by fortunate specialization.

Organic chemistry, characterized by the inertia of the bonding of the carbon atom, furnishes a vast field for the application of kinetic chemistry, while the solutions of salts, acids, and bases which are characterized by the practically instantaneous nature of a certain category of chemical reactions offer an almost inexhaustible series of chemical equilibria.

Here, however, the law of electrolytic dissociation comes to our aid, a law derived, it is true, in principle from experiments on the electric conductibility of dilute saline solutions, but which was first put on a reliable experimental footing by the osmotic method of molecular weight determination.

The importance of this doctrine extends far beyond the field of chemistry proper. Briefly described, its application to chemical processes consists in the fact

* Address before the German Chemical Society at the celebration of the fortieth anniversary of the society, November 11th, 1907. Translated in the Smithsonian Institution's annual report from Berichte der Deutschen Chemischen Gesellschaft, Jahrgang xxxx., Heft 17.

that it allows an exact application of the laws of static chemistry to characteristic aqueous solutions and through these to the reactions of ordinary analytic chemistry.

The later refinement of this doctrine has resulted in a very detailed theory of equilibrium in dilute solutions, and in particular in the proof of the fact that when, for a certain solvent, the coefficients of dissociation and solubility of those electrically neutral molecules which are composed of several combined ions are known, the equilibrium in this solvent can be calculated; and if the coefficients of distribution are known, the equilibrium in any other solvent whatever can be derived with equal facility.

On account of the simplicity of the gaseous state we should expect that the law of mass action would be particularly profitable in reference to this phase. But it was found that at low temperatures the speeds of reactions, like many of the reactions of organic chemistry, were generally very small. At high temperatures, however, equilibrium was established as in ionic reactions almost instantaneously. But in this simple field there are, at the lower temperatures, difficultly controlled catalytic influences, and at the high temperatures inherent experimental difficulties place themselves in the way. It is nevertheless to be hoped that in this field of gaseous reactions which investigators are now eagerly attacking from different points, a wealth of material and a corresponding theoretical profit will soon be forthcoming.

In the application of thermodynamics to chemical phenomena lies another field where the methods of theoretical physics have been fruitful. There, too, the first great step in advance was taken almost forty years ago. The work I allude to is that particularly important proof that the chemical law of mass action should be recognized as a direct application of thermodynamics, which is found in volume 2 of the transactions of the German Chemical Society.

Among the further results obtained in this way I should state that the aid of thermodynamics alone has made possible the close and exhaustive study of heterogeneous equilibria, particularly those where mixtures of given concentration (not only dilute solutions) enter into the equilibrium. For special cases of heterogeneous equilibria there comes into play the so-called "phase rule," which expresses in principle that in every case fixed (stable) equilibria correspond to given conditions of temperature, pressure, and concentration. This rule is therefore rather a reliable formula than a theory proper, and that is why from many sides we are warned not to exaggerate its value. More important from a theoretical standpoint is the demonstration in chemical compounds of two sorts of stability. One is the apparent stability which is characterized by the fact that its speed of decomposition is very slow (examples: Nitric oxide, hydrogen peroxide, and most organic compounds) and the other, the true stability, which is characterized by the fact that the equilibrium depends on a quantitative formation of the substance considered apart from its components.

Electrochemistry and photochemistry are governed by laws closely related to those of thermochemistry. Although the study of the latter of these two fields has presented, up to the present time, great difficulties in the way of theoretical investigation, Faraday's law, which establishes the proportion between chemical transformation and the quantity of electricity passed through a system in a given time and which thus makes possible the calculation of the electric energy necessary for a given change, has provided an accurate foundation for the application of thermodynamics to electrochemistry. Also, by continuing the special conception which gave rise to the theories of osmotic pressure and electrolytic dissociation, a simple conception of the electrochemical processes has been developed. It has at the same time become apparent that electrical forces unquestionably play a great part, not only in electrochemical phenomena, but also in many purely chemical reactions.

Thus we are brought to the problem of the nature of chemical forces. Although this question does not perhaps possess the fundamental importance that is often attributed to it, nevertheless it should be briefly considered. It can be treated here still more briefly because we are obliged to admit that during the period under consideration there has been no answer to this question which really tells us anything more than we can see with our own eyes. It seems reasonably certain that we should admit the existence, not only of electrical and therefore polar forces, but of nonpolar natural forces somewhat of the nature of Newtonian gravity. When fluorine and potassium unite to form a salt, the colossal affinity between the two elements depends at any rate in part on the affinity of the fluorine for negative electricity and of the potassium for positive electricity; but when we find in the ordinary nitrogen molecule two atoms of nitrogen united in a combination, perhaps of equal stability, it would appear that in the case of as complete an identity as presented by two atoms of nitrogen the action of polar forces should be entirely excluded. The fact that polar and nonpolar forces always act simultaneously in the production of chemical combinations is the principal reason why investigators have not yet been able to fathom the nature and the law of chemical forces, and is responsible for the fact that the investigations have not yet gotten away from a consideration of the balance of energy.

There is no need of entering here into that mooted question which has been brought up many times in physical chemistry, the question of the supremacy of the thermodynamic or the atomistic theory. This is perhaps nearly as important as determining whether Schiller or Goethe was the greater man, and should be answered in a like manner: We should rejoice in the possession of two resources so powerful and at the present time so indispensable for scientific thought. The chronicler should, however, make note of the fact that most of the modern results in the domain of physical chemistry have been obtained by a happy combination of thermodynamic methods with molecular theories, such as the creators of the modern theory of heat have followed in devoting most of their work to the development of the atomistic side, particularly of the kinetic theory.

Thermodynamics had its origin in the methods of mathematical physics. The atomic theory, on the contrary, owes its high state of perfection especially to chemical research. We should regard as a result of the latter the application of the atomic theory to the science of electricity which has begun to develop a chemical theory of electricity. There are many reasons for believing that the two forms of electricity are composed of almost infinitely small particles, each identical with the other, called "electrons." Consequently, free ions should be interpreted as combinations between the elements or radicles and the electrons, to which the laws of constant and multiple proportions apply and which likewise are governed by the theory of valence. We must limit, however, this brief indication of how the atomic theory by such a marvelous enlargement of its horizon, has put a number of physical and chemical processes in an entirely new light, and end with a few words on the radio-active emanations whose existence is made clear to us through the electron theory.

The effects of this radiation, according to the prevailing theory, are caused by the projection of electrons either in a free state or bound up with matter, and whose existence is most easily determined by the electroscope. These very recent researches have opened to us the new world of radio-active substances. For sensitiveness this method of research is often superior even to special analysis. As an example I may mention the fact that according to the calculations of a young investigator in this field, if a milligramme of radium C were divided among all the people living on the earth (about two thousand millions) each one of them would possess an amount sufficient to discharge five electroscopes, sufficient to enable him to study (with a sufficient experimental accuracy) the most important radio-active properties of each element.

The extreme sensitiveness of this reagent for radioactive substances has been the only factor which has permitted the discovery of several radio-active elements which had heretofore escaped notice because of their very small quantity or because of the brief period of their existence (in the sense of the hypothesis of atomic decomposition).

It is often easy to write history, but it is always more difficult to learn anything from the history after it is written. If I dare make a modest attempt in this direction, I should say perhaps that the chemist with such a mass of material to work on is destined in the future to prepare new compounds and to study the reactions of those already known as in the past, but that the methods of experimental and theoretical physics will be more and more called into requisition to supplement purely chemical research.

CONVERSE OF THE PRINCIPLE OF ARCHIMEDES.

By F. C. Van Dyck, Rutgers College.

The type of balance with bucket and plug employed for illustrating the principle of Archimedes may be used, in conjunction with a platform balance, for simultaneous illustration of the converse of that principle.

Referring to the figure, let the beams of both balances be made horizontal by counterpoises before the plug is immersed, the bucket being empty.

Then lower the plug into the vessel of water, step by step, balancing up each time by transferring water from the jar to the bucket. This process is perhaps familiar.

The following simple experiments are founded upon the converse of the principle of Archimedes.

No. 1.

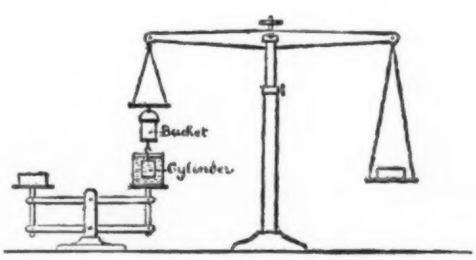
Upon one pan of an ordinary platform balance place a vessel containing water enough to submerge a body, the specific gravity of which is to be determined. Upon the other pan put any convenient counterpoise to make balance arms horizontal. A body denser than water, say a piece of iron, is suspended by a string and lowered into the water until just submerged. Then put weights on the counterpoise to make the beams horizontal, and note the sum of these weights as W. W is the weight of the water displaced by the iron. Next lower the iron until it rests on the bottom of the vessel containing the water, slacken the string, add weights to the other side until the beams are horizontal, and put the total of the weights as W'. W' is the weight of the iron "in air" (for the iron might lie on the pan outside of the vessel of water without altering W'). Hence the sp. gr. of the iron is W'/W.

No. 2.

As in No. 1 except that a body less dense than water is used; say a block of paraffined wood. Float it on the water and make the beams horizontal with weights summing up to W. W is, of course, the "weight in air" of the block. Stick a needle into the top of the block, and push it down under the water, adding weights to those already on the other pan until beams are horizontal, noting the total of the weights as W'. W' is the weight of a volume of water equal to the volume of the block. Hence W/W' is the sp. gr. of the block.

No. 3.

Balance, vessel of water, and counterbalance, as in Nos. 1 and 2. Suspend a large glass stopper, or other body denser than water, by a string and submerge it



in the water. Make the beams horizontal with weights summing up to W, which is the weight of a volume of water equal to the volume of the stopper. Then substitute for the vessel of water a vessel of another liquid, say kerosene, and counterbalance it. Submerge the stopper in the kerosene and make beams horizontal with weights amounting to W'. W' is the weight of a volume of kerosene equal to the volume of the stopper. Hence the sp. gr. of kerosene is W'/W.—School Science and Mathematics.

According to a contemporary, ferro-titanium rails were laid on October 7th, 1908, on Kessler's Curve, on the Cumberland division of the Baltimore & Ohio Railway. The curve carries heavy traffic, is of 9 deg., with 6½-inch superelevation, and is laid with 90-pound rails. In order to reach a comparison, both plain Bessemer rails containing 0.55 per cent carbon and titanium rails containing 0.48 per cent carbon were laid. When the last diagram was taken on February 12th, 1909, the wear, according to a paper by Mr. Charles V. Slocum, before the Railway Club of Pittsburg, was 4.18 pounds per yard for the plain Bessemer and 1.45 pounds for the treated or titanium rails. The former "flowed" badly and showed excessive wear and the usual indications of segregation, while the titanium rails gave every indication that the steel was perfectly solid and homogeneous.

THE SIX HUNDREDTH ANNIVERSARY OF THE TURRET CLOCK.

The following is reported from Milan: The six hundredth anniversary of the turret clock has passed unnoticed here. In the last days of December, 1309, the first turret clock was erected in Milan on the tower of the San Eustorgio. For many years this clock was considered a marvelous piece of work, and learned men and curious sightseers came from all parts to gaze upon the wonderful mechanism. From this time the art of clock making made rapid progress. As early as 1344 a turret clock was erected on the tower of the Signorina in Padua, showing the hours, the path of the sun, the orbits of the planets, the solar eclipses, the months, and the annual festivals. The first alarm clock of which we have any record was mentioned in the Milan chronicles in 1430. The Councilor Andrea Alfiato was the owner of this clock, which however operated only at a fixed time, 7 in the morning. The alarm sounded, and at the same moment a small taper, automatically ignited, burst into flame.

[It seems rather doubtful, however, if Milan can really claim the distinction of being the birthplace of the tower clock, for according to the "Lexikon der Uhrmacherkunst" (Encyclopedia of Horology) one was installed in Westminster Hall, London, in 1288 and in Florence, Italy, in 1300, Milan being accorded third place.—Ed.]

Correspondence.

RULE FOR SQUARING CERTAIN NUMBERS.

To the Editor of the Scientific American:

In your February 12th issue I noticed "Curious Facts About Squares and Cubes." The latter part of that article is as follows: "I can furnish you with a device if you desire it by means of which, the squares of the numbers 1 to 25 being given, the square can be written off in order *ad libitum* without any multiplication." Having read this, I noticed particularly, "The squares of the numbers 1 to 25 being given." I have seen a good many articles on the subject of curiosities about numbers, etc., but have never seen anyone publish an easy method for squaring numbers such as 15, 25, 35, 45, etc. (You notice I leave out 20, 30, 40, etc., as these are simple, as it is only the squaring of the tens.)

The rule for squaring numbers such as I have given is as follows:

First—Square the unit as in 15 is 5 and $5^2=25$.

Second—Square the tens which is 1 and $1^2=1$ and add itself $=1$ plus $1=2$. The answer is therefore 225.

In other words, 15 squared is easily found by squaring the units as above, and the second operation by adding 1 to number; thus 1 plus $1=2$ and $2\times1=2$.

Thus 125 squared $=15{,}625=5^2$ and 12^2 plus 12 or 5^2 and 12×13. While it is hardly likely one would want to attempt any mental calculations of numbers, such as 126, 127, 128, etc., these are easily figured from the fact that we know, say in the case of 21, that we must have three figures in the answer. Thus if we square $1=1$, and knowing that we must have three figures we put a 0 between the 2^2 plus $2=6$, giving 601, and for each number that we are below the nearest number we can readily square, that is 25. In this case if we take the difference between 21 and 25 and multiplying the difference by 2, which $=4\times2=8$, and instead of considering the number as 21 we consider it as 20 and $20\times8=160$ and 601 minus $160=441$, the square of 21. If the number was 29 we would then add instead of subtracting, then the operation would be: 29^2 as above rule would be 681; then $20\times8=160$, 681 plus $160=841$.

Similarly with 129 would $=15{,}681$

$$\begin{array}{lr} & 15{,}681 \\ 120\times8=960 & 960 \\ \hline & 16{,}641 \end{array}$$

or with $121=15{,}601$. Note the 0.

$$\begin{array}{lr} & 15{,}601 \\ 120\times8= & 960 \\ \hline & 14{,}641 \end{array}$$

In a similar way such numbers as 155, 255, etc., and 955 may be squared, not mentally, but by a "shorthand" method. I won't give any rule, but an example will show what is done:

$$\begin{array}{rr|l} 955^2= & 95 & 5 \\ & 95 & 5 \\ \hline & 9025 & 25 \\ & 95 & \\ \hline \text{Answer} & 9120 & 25 \end{array}$$

Note the difference in operation as compared with such numbers as 15, 25, etc.

I have tried to condense the "rule" as much as possible, and I think that it is clear as necessary, as there is nothing but elementary arithmetic used.

If you think this may interest your readers, you are at liberty to publish it. A. Delgado.

Schenectady, N. Y.

ROSIN SOAPS.

A German paper states that Messrs. W. Daffert and J. Woltbauer have conducted a series of experiments with soaps containing no rosin and such containing 10 and 30 per cent of it, in order to determine their washing value. The tests have shown that contrary to the opinion generally held, the resinous soaps have less value than those without rosin, all other things being equal. The yield in washing diminishes with the content of rosin increasing. In no case was rosin found to be favorable.

Staybolts of electrolytic copper have given bad results in locomotives on Prussian railways in the last few years, according to a statement by Mr. Metzeltin in the Zeitschrift des Vereines Deutscher Ingenieure. An unusual number of staybolt fractures occurred during recent years, in a period when electrolytic copper was adopted as material, in place of furnace copper. As many of the fractures occurred on wide fire-boxes there was doubt as to whether the construction or the material was responsible. Staybolts that broke were therefore collected, for a period, and tested; of twenty-three samples it was found that only two were of furnace copper and twenty-one of electrolytic copper. Of the electrolytic samples only one contained arsenic, while all the staybolts of furnace copper showed arsenic. The Italian railways and the railways of the British colonies, is is stated, specify a percentage of 0.15 to 0.55 per cent arsenic in copper.

SCIENCE NOTES.

Prof. Neesen has made at Krupp's factory an experimental investigation of the course of projectiles. In order to make it possible to follow the movement of the projectile during flight, he employed smoking projectiles by day and luminous projectiles at night and in the twilight. The light was produced by a magnesium flame issuing laterally from the projectile. Owing to the rotation of the projectile, the flame appeared intermittently. By comparison of the duration of appearances and eclipses it was possible to estimate the extent of vibration, and to obtain other interesting data. In some of the experiments projectiles fired from a mountain howitzer of three inches caliber, with an initial velocity of 1,000 feet per second and making 160 revolutions per second, were employed.

The chief test of the success of a scientific hypothesis and of a train of reasoning therefrom is found in the ability to make predictions. Of this probably the most striking example in all science is the law of gravitation. All the observations of the last two hundred years have only resulted in confirming Newton's conclusion, while the accuracy of astronomical prediction exceeds that of any part of science. Such is an example of scientific faith. Another famous example is Hamilton's famous discovery of conical refraction. On looking through a piece of Iceland spar at an object one sees it doubled. The laws of this double refraction had been thoroughly described by Fresnel, who related them to a certain geometrical surface invented by him. By the study of the geometry of this surface, which was found to possess two singular points, Hamilton showed that on looking through the crystal in a certain direction at a point, one would see not two points but a whole continuous circle. This experiment was made by Hamilton's friend Lloyd, who saw the circle, confirming in the most brilliant manner the wonderful imagination of Hamilton, who saw in his mind's eye what never yet man had seen.

Of the natural sciences there are two fundamental ones, physics and biology. Physics has to do with all the universe, in so far as it possesses energy, and exerts forces one part upon another, and in so far as it does not possess life. Biology deals with all matter possessing this difficultly defined attribute, but so far as we know, even the phenomena of living matter are subject to the laws of physics. Every biologist will admit that life does not create energy, but merely directs it. Nevertheless, the question of vitality is to-day far beyond the explanation of the physicist. The subdivisions of physics have been, for convenience only, set off as individual sciences, chiefly because the whole subject would be too large for the treatment of any individual scientist. The most important part of physics is dynamics, which treats of the laws of motion, and the forces which are associated therewith. Of this a great division is celestial mechanics, which, as we have seen in the cases of Galileo and Newton, contributed in great part to the inductive establishment of the laws of motion in general. The remainder of astronomy is now catalogued as astrophysics and is dealt with by purely physical methods and instruments. As a subdivision of astronomy may be reckoned geodesy, which deals with the form of the earth, deduced from astronomical measurements and from its gravitational attraction.

Chemistry is that part of physics which deals with the properties of substances that have individual characteristics by which they may be always distinguished, and which combine with each other in definite proportions. Its methods are those of physics, its main instrument is the physical balance, and it is in recent years concentrating more attention upon those physical relations connected with temperature, pressure, and electrical relations, all of which are now found to yield to mathematical treatment in a manner until recently unsuspected. The methods of physics and chemistry usually involve the controlling of certain of the circumstances under which phenomena occur, so that the changes in others may be more easily observed. This is usually done in a laboratory furnished with many means of controlling circumstances, for instance, temperature, pressure, electrical or magnetic state, so that the same circumstances may be reproduced again and again. Meteorology, or as it is now somewhat grandiloquently called, cosmical physics, has to do with those phenomena of the atmosphere, the ocean, or the magnetic state of the earth, which are not controllable by man, and which cannot, therefore, be repeated at pleasure in the laboratory, but must be observed when and where they occur. The same applies to geology, which is the application of physics, chemistry and even biology, or any science whatever, to the earth, in relation to its physical constitution and its history. Geography deals with the face of the earth, and uses the results of geology to study the earth as fit to be the dwelling place for man. There remain the technical applications of physics in all kinds of engineering, civil, mechanical, electrical, chemical or mining, involving the strength of materials, elasticity and the direction of the natural sources of energy to the purposes of man. All these applications of physics need, and are highly susceptible to, mathematical treatment, and for that reason they are the most perfectly developed of all the sciences.

TRADE NOTES AND FORMULÆ.

To Mend Leaking Lead Pipe While the Water is Running in It.—The leak is made wider and very quickly pieces of wheaten bread stuffed in, pushing it in in the direction whence the water comes. The hole can then be quickly closed by soldering a patch on it.

Paint for White Leather Work.—Take 20 parts of zinc white, 20 parts of white bole and sufficient ultramarine, carefully mixed. This powder to be incorporated by rubbing in a solution of 12 parts of white shellac in 40 parts of alcohol.

Asbestos Paint (fireproof, for wooden structures).—30 parts ground asbestos, thoroughly mixed with 20 parts of clay, 30 parts of water, 10 parts borax, and 10 parts water glass, warmed for a time, ground, and the color added.

Paint for Tin Roofs.—Take 30 parts linseed oil, 10 parts oil of turpentine, 14 parts English red, and 46 parts chalk. The coloring substance must be crushed fine, the mixture rubbed down in a paint mill, finally thinned with equal parts of oil of turpentine and linseed oil. The tin must be free from rust.

Plastic Asbestos Mass (J. E. G. Merann).—Reduce asbestos to powder, from which, by mixing with water and stirring, a homogeneous mixture is prepared. Then, adding more water, a paste is produced which is allowed to thicken by drying, until the mass acquires the desired plasticity. Objects formed from this mass, after being dried for a time, may finally be burned in a furnace.

Matt Black Varnish for Picture Frames and Furniture.—Take 13 parts of shellac, 8 to 10 parts spirits of sal. ammoniac, 1 to 2 parts sal. ammoniac, 0.25 part potash, 1 to 2 parts extract of logwood, 0.75 to 1 part lamp black, 0.25 part boracic acid, 0.25 part blue vitriol and 75 parts water. The varnish dries quickly and dead black with a velvety surface, adheres very durably on wood and will stand washing.

Flash Light Powder for Instantaneous Photographic Exposures.—Small cylindrical cartridge shells, made from the finest card, are filled with the flash light powder, 13.6 parts anhydrous perchlorate of potash and 9.6 parts powdered magnesium thoroughly mixed with the help of a feather. On this is placed a pinch of igniting salt, 1 part milk sugar and 3 parts chlorate of potash, mixed, and over this a thin layer of gun cotton, the latter projecting at one point beyond the edge of the tissue paper-covered cylinder. The cartridges are not expensive and can be burned in the hand.

Grafting Wax.—In an iron pot melt over the fire, 100 parts of the finest asphalt, add 600 parts brown pitch until, with stirring, it is fluid, then pour in 600 parts of melted yellow beeswax. The fire must not be too hot at this time. When it is all well mixed, add 600 parts of thick turpentine, stir it well and pour into it 600 parts of refined tallow. Lift it from the fire, stir until you begin to note that it is cooling and then drop in, stirring steadily, very carefully, because the mass will at once rise up, 250 to 500 parts of alcohol, according to the consistency we wish it to have.

Barometer Paper.—To aqueous solution of sulphate of cobalt add solution of sulphocyanide of potassium as long as sulphate of potash is separated. Allow the latter to settle, transfer it to a filter and wash it out with alcohol: use the fluid at once or concentrate it somewhat by evaporation (in the water bath at a low temperature). Brown: 1 part bromide of potassium, 1 part sulphate of copper, dissolved in 20 parts of water. Yellowish Green: Dissolve in 20 parts of water 0.5 part of chromate of cobalt, 1 part nitric acid, 1 part common salt, slightly warmed. Yellow: Equal parts common salt and chloride of cobalt, dissolved in 20 parts water. Pictures printed with these solutions change color according to the small or large quantity of moisture contained in the atmosphere.

TABLE OF CONTENTS.